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Collaborative learning utilizing a domain-based shared data repository to enhance learning outcomes

David J. Lubliner
New Jersey Institute of Technology

ABSTRACT

COLLABORATIVE LEARNING UTILIZING A DOMAIN-BASED SHARED DATA REPOSITORY TO ENHANCE LEARNING OUTCOMES

by
David J. Lubliner

A number of learning paradigms have postulated that knowledge formation is a dynamic process where learners actively construct a representation of concepts integrating information from multiple sources. Current teaching strategies utilize a compartmentalized approach where individual courses contain a small subset of the knowledge required for a discipline. The intent of this research is to provide a framework to integrate the components of a discipline into a cohesive whole and accelerate the integration of concepts enhancing the learning process. The components utilized to accomplish these goals include two new knowledge integration models; a Knowledge Weighting Model (KWM) and the Aggregate-Integrate-Master (AIM) model. Semantic Web design principles utilizing a Resource Description Framework (RDF) schema and Web Ontology Language (OWL) will be used to define concepts and relationships for this knowledge domain that can then be extended for other domains. Lastly, a Design Research paradigm will be utilized to analyze the IT artifact, the **C**onstructivist **U**nifying **B**accalaureate **E**pistemology (CUBE) knowledge repository that was designed to validate this research.

The prototype testing population utilized sixty students spanning five classes, in the fall 2007, following IRB approved protocols. Data was gathered using a Constructivist Multimedia Learning Survey (CMLES), focus groups and semi-structured

interviews. This preliminary data supported the hypotheses that students using the Integrated Knowledge Repository will first; have a more positive perception of the learning process than those who use conventional single course teaching paradigms and second; students utilizing the IKR will develop a more complex understanding of the interconnected nature of the materials linking a discipline than those who take conventional single topic courses.

Learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. The goal is to develop a knowledge structure that is capable of facilitating the integration of conceptual development in a field of study.

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by
David J. Lubliner

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COLLABORATIVE LEARNING UTILIZING A DOMAIN-BASED SHARED DATA REPOSITORY TO ENHANCE LEARNING OUTCOMES

David J. Lubliner

9/18/08

Dr. George Widmeyer, Dissertation Co-Advisor — Date
Associate Professor of Information Systems, NJIT

9/18/08

Dr. Fadi Deek, Dissertation Co-Advisor — Date
Dean, College of Science and Liberal Arts
Professor of Information Systems, Information Technology and Mathematical Sciences, NJIT

9/18/08

Dr. Julian Scher, Committee Member — Date
Associate Professor of Information Systems, NJIT

9/18/08

Dr. Thomas Juliano, Committee Member — Date
Associate Professor of Engineering Technology, NJIT

9-18-08

Dr. William Tereshkovich, Committee Member — Date
Vice President Application, Availability and Stability & Architecture, UBS

BIOGRAPHICAL SKETCH

Author: David J. Lubliner

Degree: Doctor of Philosophy

Date: January 2009

Undergraduate and Graduate Education:

- Doctor of Philosophy in Information Systems,
  New Jersey Institute of Technology, Newark, NJ, 2009

- Master of Science in Electrical Engineering,
  New Jersey Institute of Technology, Newark, NJ, 1981

- Master of Science in Computer Science,
  New Jersey Institute of Technology, Newark, NJ, 1977

- Bachelor of Science in Mathematics/Physics,
  Ramapo University, Mahwah, NJ, 1974

Major: Information Systems

Publications, Presentations and Grants:

David Lubliner and George Widmeyer,
"N^2 Heads are better than one: collaborative learning, utilizing an integrated knowledge repository, facilitated through a massively multiplayer online gaming (MMOG) paradigm," 41st Annual Hawaii International Conference on System Sciences, Manoa, Hawaii, January 2008.

David Lubliner, Joshua Greenfeld, and Harry Roman,
"Automated meter inspection and reading: computer vision recognition system for obtaining visual indicia from exposed faces of electric meters," $480,000 Grant PSEG, Newark. NJ.
Patent 5,559,894 issued September 24, 1996.

To my family

Without whose support and encouragement this degree would have not been possible

Cathy, Amy, Lindsay and Zach

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CHAPTER 1

INTRODUCTION

1.1 Background

A number of learning paradigms have postulated that knowledge formation is a dynamic process where learners actively construct a representation of concepts, integrating information from multiple sources. However, current teaching strategies still utilize a compartmentalized approach, where individual courses contain a small subset of the knowledge required for a discipline. It has been hypothesized (Turoff, 2006) that *"Ultimately the development of content knowledge bases that integrate content across multiple courses within a degree program is an expected evolution."* The task of integrating these distinct pieces of the puzzle is usually the responsibility of the learner. The intent of this research was to provide a structure, several models, and a prototype knowledge repository to realize this goal of creating a dynamic integrated learning environment spanning an entire discipline.

In order to validate this approach a system called **C**onstructivist **U**nifying **B**accalaureate **E**pistemology (CUBE), has been developed to integrate the materials from multiple college courses. CUBE is a dynamic environment that incorporates student input to ensure the evolution of the knowledge base. A generic structure has been developed to allow other disciplines to utilize this framework. The central hypothesis is that students utilizing the Integrated Knowledge Repository (IKR) will develop a more complex understanding of the interconnected nature of the materials linking a discipline than those who take conventional single topic courses.

In order to realize this interconnected knowledge repository, the current constructivist learning environment was extended to incorporate a formal relationship between the building blocks of knowledge formation. The evolutionary components of factual knowledge, conceptual knowledge, procedural knowledge and meta-cognitive knowledge, presented in Bloom's revised taxonomy (Anderson et al. 2000), were integrated into a Knowledge Weighting Model (KWM). The factual elements and course materials form the basic elements that are interconnected with a concept-weighting structure that forms an integrated conceptual knowledge. Procedural knowledge was further constructed using a knowledge map that displays the skills and algorithms as they evolve from basic to more sophisticated applications in a discipline. Finally, the meta-cognitive component that captures the structure of a subject matter as cognitive tasks was correlated using field relevance structure that ties together the philosophical underpinning of a discipline.

The first step was to find an instructional design theory that supports this approach. This research utilizes the Constructivist Learning Environment (CLE) (Dede, 1995) (Jonassen, 1991) which is an instructional design theory that is based on the concept that learners actively construct a knowledge representation in working memory based on six components.

These components are:

- active-manipulative
- constructive
- collaborative
- reflective-critical

- complex, and
- intentional.

These six components create a structural framework to engage students in meaningful learning. In addition, the Revised Bloom's Taxonomy (Anderson et al. 2000) organizes knowledge formation as an evolutionary growth from factual to conceptual to procedural knowledge. Finally, the overall structure of a discipline is woven together into meta-cognitive knowledge where cognitive tasks, and how we structure our own knowledge, are formed. These theories form the basis of the hypotheses that extend constructivist theory to connect all these stages of knowledge formation.

The second step was to develop a Knowledge Weighting Model (KWM) which integrates the individual course topics, common elements between the materials, correlation weights as to the interdependence of the variables and finally the evolving relevance of existing and new material to the overall growth of the discipline.

The third step was to develop an environment to facilitate students' ability to easily and intuitively access large volumes of factual knowledge. This was accomplished by creating a cube structure to display, integrate and facilitate information retrieval across multiple courses. In addition, a knowledge map linked conceptual threads spanning courses into an evolving conceptual framework. These concepts were integrated into the overall design of the user interface and system.

The fourth step was to select a discipline, Computer Technology, to test out the hypotheses that an integrated learning environment, spanning an entire discipline, would enhance learning and comprehension of the interconnected complexities inherent in any discipline. Four well-defined courses, that span introductory to advanced topics, were chosen to create this knowledge repository. The courses are: Computer Architecture, Introduction to Networks, Advanced Network Theory and Medical Informatics. All the course notes have been collected and the cooperation of the instructors has been obtained to test this system. A control group was used to test learning efficacies. Components of the Computer Information Systems Security Professional (CISSP) exam will be used to test the accumulated knowledge, skills and comprehension.

1.2 Research Questions

This dissertation focuses on the development of more effective learning and information processing tools and models to enhance the goals of Constructivist Learning Theory that states, "Learning, as knowledge construction, is based on the concept that learners actively construct a knowledge representation in working memory." (Jonassen, 1991). Enhancing knowledge construction, by developing an Integrated Knowledge Repository (IKR), that spans an entire discipline, will facilitate students' ability to traverse the road of knowledge and will enhance and accelerate knowledge formation. This Integrated Knowledge Repository incorporates the ability to select individual paths and tailor the learning experience to their own individual abilities and learning styles.

It also builds on the Selection-Organization-Integrate (SOI) Knowledge Construction Model (Mayer, 1996), that theorizes that selecting and integrating concepts for a particular course or text, can form the basis for a more dynamic and expansive learning experience model. This research introduces an Aggregate Integrate Master (AIM) model that hypothesizes that, rather than having individual instructors or students extract relationships between concepts, the core knowledge of a discipline, representing N number of courses, can be integrated to facilitate conceptual synthesis of concepts.

Integrating concepts from the Semantic Web, the knowledge repository was structured using a *Semantic Web model.* The Semantic Web is a "set of formats and languages that are used to find and analyze data on the web" (Feigenbaum, 2007) (Berners-Lee, 2001). A number of standards, published by the World Wide Web Consortium Semantic Web Activity Initiative, utilize the Resource Description Framework (RDF). Each piece of data and any link that connects pieces of data are identified by a unique name called a Universal Resource Identifier (URI). In the RDF scheme, two pieces of information are connected and grouped together in a triplet to infer relationships between concepts. This will ensure that a standard vocabulary and relationships between concepts will be maintained and provide a platform for future growth.

The last component utilizes a Design Research paradigm. Design Research involves the analysis of the use and performance of designed artifacts to understand, explain and very frequently to improve on the behavior of aspects of Information Systems" (Association for Information Systems (AIS)). Design Evaluation Methods (Hevner et al. 2004) were used to evaluate the Information Technology artifact.

The **C**onstructivist **U**nifying **B**accalaureate **E**pistemology (CUBE), that provides metrics for data analysis, was used to validate this research. The efficacy of an artifact can be demonstrated by the appropriate selection of design evaluation methods (Basilli, 1996) (Zelkowitz & Wallace, 1998). The categories for the design evaluation methods metric are: functionality, completeness, consistency, accuracy, performance, reliability, usability and fit within an organization/university context. The design phase is iterative and provides feedback during development.

1.3 Importance of This Research to the Field of Information System

This research is important to the research community for several reasons. First, there is currently no existing model, face-to-face or online, to interconnect courses that share philosophical and technical commonalties into a collaborative learning environment, utilizing a shared knowledge repository. The second benefit of this research is to introduce two new models; the **K**nowledge **W**eighting **M**odel (KWM) and the **A**ggregation-**I**ntegration-**M**aster (AIM) Knowledge Construction Model are introduced to provide a structure for future knowledge repositories. The third benefit of this research validates the Constructivist Learning Environment (CLE) approach to learning that emphasizes knowledge construction. The fourth benefit provides a generic tool, CUBE, that fosters the learner's process of organizing and integrating information. This can serve as a platform for others to develop future knowledge repositories.

1.4 Organization of the Dissertation

Chapter 2 is comprised of a literature review that builds a theoretical foundation for this research. The chapter is organized into Constructivist Learning, theories of learning, knowledge construction, knowledge mapping techniques and theories of distributed cognition, focusing on their relevance to creating a unified knowledge repository, which is a key component of this research. The extensibility of the knowledge repository, a system design principle where the implementation takes into consideration future growth and compatibility with other systems which utilize the Semantic Web model, is discussed in this section.

Chapter 3 contains a description of the research, the hypotheses that were tested, data collection techniques and the pilot testing that has indicted the efficacy of this approach to enhanced learning and cognition. In addition, the data structures of the CUBE (**C**onstructivist **U**nifying **B**accalaureate **E**pistemology) prototype, that has been developed to test and validate this research, are described.

Chapter 4 presents the data collection and analysis strategies for this research. Two new models, the **K**nowledge **W**eighting **M**odel (KWM) and the **A**ggregation-**I**ntegration-**M**aster (AIM) Knowledge Construction Model, are introduced to provide a theoretical framework for this research. The Constructivist Learning Questionnaire, which has been validated by other researchers, was used to collect data on the new system.

CHAPTER 2

LITERATURE REVIEW

This section describes various learning theories that have evolved over the last hundred years. These theories form a foundation for the Constructivist Learning Environment (CLE) that was utilized in the development of the integrated knowledge repository described in this research.

2.1 Introduction: Constructivism

Constructivism postulates that learners construct knowledge for themselves. Individually and socially they construct meaning as they learn. The goal of this research is to develop a new paradigm, building on the constructivist theory that will allow students to more effectively integrate knowledge spanning a discipline than current instructional models. The current approach is to present students with pieces of a puzzle, independent courses spanning several years, and hoping that at the end of their journey they will integrate these concepts into a cohesive unit. In other words, the student must assemble the puzzle. That synthesis often fails to occur. The goal of this research is to present, from the beginning, all materials in a core knowledge repository, with conceptual connections embedded, to enable students to construct threads tying together a discipline at every step of their intellectual journey. This chapter explores the evolution of constructivist theory and other learning theories that contribute to the development of this new paradigm.

2.2 Knowledge Construction

How learning occurs, and various effective techniques of organizing information into a coherent synthesis, that maximizes knowledge construction and hopefully leads to the attainment of wisdom, have been debated throughout history. Many of the basic terms have multiple definitions and interpretations. The complexity of these concepts and number of interpretations expand exponentially as one traverses from the building blocks or data defined by experimental rigor to the eventual integration of individual facts into a coherent structure that leads to an understanding of more complex interrelationships.

This research focuses on the development of more effective learning and information processing tools and models to enhance the goals of Constructivist Learning Theory which state that, "learning as knowledge construction is based on the concept that learners actively construct a knowledge representation in working memory," (Jonassen, 1991). Enhancing knowledge construction by developing a knowledge repository, that spans an entire discipline, will facilitate students' ability to select their own individual paths and tailor the experience to their own individual abilities and learning styles. A Concept Weighting Model has been developed to quantify relationships between individual concepts that interconnect a discipline.

2.3 Learning Theories

This section discusses various learning theories that describe how people learn and the complex processes that underlie learning. They can be classified as Behaviorism, Cognitivism and Constructivism.

Learning behaviors will also be discussed in this section. In particular, Constructivist Learning will be examined as it pertains to the development of this dissertation. Distributed Cognition, a field of psychology developed by Edwin Hutchins, which emphasizes the social effects on cognition, is particularly relevant, not only because of individual interaction with the knowledge repository, but also because of the effects of social interaction on knowledge construction.

2.3.1 Behaviorism

Behaviorism can be defined as the theory that human or animal psychology can be accurately studied only through the examination and analysis of objectively observable and quantifiable behavioral events (*Webster's College Dictionary*, 1993). It concentrates on the study of overt behaviors that can be observed and measured (Good & Brophy, 1990). In regard to learning theories, it is based on behavioral changes which focus on new behavioral patterns being repeated until they become automatic (Schuman, 1996). The behaviorist learning theory centered on that which was observable, not considering that there was anything occurring inside the mind.

Behaviorism can be found as early as Aristotle in his essay entitled, "Memory," which made associations based on external events, in particular lightning and thunder. Later, Hobbs (1650) and Hume (1740) mentioned similar associations between observable facts and resulting behaviors. Pavlov, the Russian psychologist, studied conditioning, using a dog, food and a bell (famous Pavlov's dog experiment) where the dog was trained to respond to stimuli which mimicked the effects of actual responses, called, "stimulus conditioning."

Edward Thorndike (1898) set out to apply "the methods of exact science" to educational problems by emphasizing "accurate, quantitative treatment of information."

"Anything that exists, exists in a certain quantity and can be measured." His theory, Connectionism, stated that learning was the formation of a connection between stimulus and response. Learning takes place when the bonds are formed into patterns of behavior.

John B. Watson (1913) built on Pavlov's work and believed that humans are born with a few reflexes and the emotional reactions of love and rage. All other behavior is established through stimulus-response associations through conditioning. His work demonstrated the role of conditioning in the development of emotional responses to certain stimuli.

Skinner (1948), like Pavlov, Watson and Thorndike, believed in the stimulus-response pattern of conditioned behavior. His theory dealt with changes in observable behavior, ignoring the possibility of any processes occurring in the mind, and refers to a utopian society, based on operant conditioning. Skinner's work on operant behavior differed from that of his predecessors by focusing on voluntary behaviors used in operating on the environment. Skinner believed in positive reinforcement or reward; responses that are rewarded are likely to be repeated. For example, good grades reinforce careful study.

2.3.2 Cognitivism

The Cognitive approach to learning states that learning involves the formation of mental associations, established through contiguity and repetition, that are not necessarily reflected in overt behavior changes. Individuals are actively involved in the learning process and learning is a process of relating new information to previously learned information.

In the 1920's, limitations to the behaviorist approach stated that children need reinforcement to learn effectively. Cognitive theorists view learning as involving the "acquisition or reorganization of the cognitive structures through which human's process and store information." (Good & Brophy, 1990). Later, Bandura and Walters (1963) stated that an individual could model behavior by observing the behavior of another person. This led to Bandura's Social Cognitive Theory.

2.3.3 Constructivism

Constructivists believe that learners, "construct their own reality or at least interpret it, based upon their perceptions of experiences, so an individual's knowledge is a function of one's prior experiences, mental structures, and beliefs that are used to interpret objects and events." (Jonasson,1991). "What someone knows is grounded in perception of the physical and social experiences, which are comprehended by the mind." (Jonasson, 1991).

Based on the premise that everyone constructs their own perspective of the world, through individual experiences and schema, Constructivism focuses on preparing the learner to problem solving in ambiguous situations. This theory was first introduced by Bartlett (1932) and later became the Constructivist approach (Good & Brophy, 1990).

Merill (1991) believed that:

1) Knowledge is constructed from experience,
2) Learning is a personal interpretation of the world,
3) Learning is an active process, in which meaning is developed on the basis of experience,

4) Conceptual growth comes from the negotiation of meaning, the sharing of multiple perspectives and the changing of our internal representations through collaborative learning,

5) Learning should be situated in realistic settings, and

6) Testing should be integrated with the task and not a separate activity.

Table 2.1 Origins of Behaviorism, Cognitivism and Constructivism

Theory	Researcher	Theories/ Conclusions	Dates
Behaviorism			310 B.C.
	Aristotle	Essay, "Memory" Association between events such as lightning and thunder	310 B.C.
	Ivan Pavlov	Pavlov's Experiment: A dog is trained to respond to a bell for food, salivates even when food is not present	1891
	Edward Thorndike	Connectionism Learning was the formation of a connection between stimulus and response	1911
	John Watson	Behavior is established through stimulus-response associations through conditioning.	1913
	B.F. Skinner	passive, just responding to stimuli stimulus-response pattern of conditioned behavior	1938
Cognitivism			
	Jerome Bruner	Discovery Learning Learners process, store, and retrieve information for use.	1947
	Lev Vygotsky	Zone of Proximal Development Interactive problem solving.	
	Edward Tolman	*Purposive Behavior in Animals and Men* Animals could learn facts about the world that they could subsequently use in a flexible manner, rather than simply learning automatic responses that were triggered off by environmental stimuli	1932

Table 2.1 Origins of Behaviorism, Cognitivism and Constructivism (Continued)

Theory	Researcher	Theories/ Conclusions	Dates
	Good and Brophy	That much learning involves associations established through contiguity and repetition	1990
Constructivism			
	Albert Bandura	Social Cognitive Theory (Dembo, 1994).	1994
	Jean Piaget	He believed that "the learner must be active; he is not a vessel to be filled with facts"	1920
	Fredrick Barlett	Definition of Schema An active organization of past reactions, or past experiences	1932
	Bruner	Learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge	1960
	Knowles	Knowles' Andragogy - Learners have a mutual interest in their learning and need to involve real experience. Teachers are not the sole possessors of knowledge: but co-learners and guides	1990
	Good and Brophy	Learners, construct their own reality, or at least interpret it based upon their perceptions of experiences.	1990
	Jonasson	What someone knows is grounded in perception of the physical and social experiences which are comprehended by the mind.	1991
	Merrill	Knowledge is constructed from experience. Learning is a personal interpretation of the world	1991
	Schank	All human behavior is goal directed.	1994

2.4 Taxonomic Analysis Learning Behaviors

The following section describes several learning taxonomies, including Bloom's, Revised Bloom's and Gagne's learning taxonomy, that categorize the components of learning and knowledge formation.

2.4.1 Bloom's Taxonomy

Benjamin Bloom (1956) developed a classification of levels of intellectual behavior in learning. This taxonomy contained three overlapping domains: the cognitive, psychomotor, and affective. Within the cognitive domain, he identified six levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. *Knowledge* is a starting point that includes both the acquisition of information and the ability to recall information, when needed. *Comprehension* is the basic level of understanding. It involves the ability to know what is being communicated in order to make use of the information. *Application* is the ability to use a learned skill in a new situation. Analysis is the ability to break content into components in order to identify parts, see relationships among them, and recognize organizational principles. *Synthesis* is the ability to combine existing elements in order to create something original. *Evaluation* is the ability to make a judgment about the value of something by using a standard (Bloom, 1956).

2.4.2 Bloom's Revised Taxonomy

In order to update Bloom's work relative to today's theories, Anderson and Krathwohl (2001) revised Bloom's original taxonomy by combining both the cognitive process and knowledge dimensions.

In the revised taxonomy, Bloom's six major categories were changed from noun to verb forms. Additionally, the lowest level of the original, *knowledge,* was renamed and became, *remembering.* Finally, *comprehension* and *synthesis* were renamed to *understanding* and *creating.* The updated version has also added *metacognitive* to the array of knowledge types. *Metacognitive Knowledge* is the awareness of one's own cognition and particular cognitive processes. It is strategic or reflective knowledge about how to go about solving problems and cognitive tasks, to include contextual and conditional knowledge and knowledge of self.

The revised taxonomy incorporates both the kind of knowledge to be learned (knowledge dimension) and the process used to learn (cognitive process), allowing for the instructional designer to efficiently align objectives to assessment techniques. Both dimensions are illustrated in the following table that can be used to help write clear, focused objectives.

Table 2.2 Revised Taxonomy Table

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge						
Procedural Knowledge						
Meta-cognitive Knowledge						

2.4.3 Gagne's Taxonomy of Learning

Gagné's work, "Conditions of Learning and Events of Instruction" (Gagné, 1965), called Instructional Systems Development (ISD), related the existing learning theories to each other and assigned to each theory its relative position with regard to their diverse learning domains. Gagné based the main part of his approach on Bloom's taxonomy of learning objectives, and integrated the different learning theories that had been developed, from behaviorism to cognitivism. The classification of learning, according to Robert Gagné, includes five kinds of learning capabilities. The first three, which include intellectual skills, cognitive strategies and verbal information, are based on Bloom's theories of cognitive development. The last two, attitudes and motor skills, relate to Bloom's affective and physical motor domain. The Gagné taxonomy is a popular learning taxonomy in the field of instructional design (Reigeluth, 1983). Its popularity can be attributed to its ability to clearly distinguish between abstract and concrete definitions of learning (Seels & Glasgow, 1990).

Gagne's ideas of instruction are what he calls "conditions of learning." He breaks these down into internal and external conditions. The internal conditions deal with previously learned capabilities of the learner. Or, in other words, what the learner knows prior to the instruction. The external conditions deal with the stimuli (a purely behaviorist term) that are presented externally to the learner. His approach is relatively rigid, a cookbook approach, and does not provide the flexibility needed for constructive learning which allows students to construct their own knowledge representation.

2.5 Social Constructivism

Social constructivism, developed in sociology and philosophy, emphasizes the importance of culture and context in understanding what occurs in society and constructing knowledge, based on this understanding (Derry, 1999) (McMahon, 1997). This perspective is closely associated with many contemporary theories of Vygotsky and Bruner, and Bandura's social cognitive theory (Shunk, 2000).

Social constructivism is based on specific assumptions about reality, knowledge, and learning. To understand and apply models of instruction that are rooted in the perspectives of social constructivists, it is important to know the premises that underlie them. *Reality:* Social constructivists believe that reality is constructed through human activity. Members of a society together invent the properties of the world (Kukla, 2000). For the social constructivist, reality cannot be discovered; it does not exist prior to its social invention. *Knowledge:* To social constructivists, knowledge is also a human product, and is socially and culturally constructed (Ernest, 1999) (Gredler, 1997) (Prat & Floden, 1994). Individuals create meaning through their interactions with each other and with the environment in which they live. *Learning:* Social constructivists view learning as a social process. It does not take place only within an individual, nor is it a passive development of behaviors that are shaped by external forces (McMahon, 1997). Meaningful learning occurs when individuals are engaged in social activities.

2.6 Constructivist Learning Environment

There are three major approaches to learning that have evolved during the last century:

- Behavioral: Learning as response strengthening,
- Cognitivist: learning as knowledge acquisition, and
- Constructivist: learning as knowledge construction (Mayer, 1992).

Behaviorism focuses on observable changes in behavior, where a new behavioral pattern is repeated until it becomes automatic. Behaviorism did not account for many types of learning, such as social behaviors and levels of cognitive reasoning (Tolman, 1932) where rats showed higher cognitive reasoning by storing mental maps of mazes. Cognitivism "recognize that much learning involves associations established through continuity and repetition" (Good & Brophy, 1990). Constructivists believe that our construction of reality is more complex than simple association described in Cognitivism. Constructivists believe that "learners construct their own reality, or at least interpret it, based upon their perceptions of experiences," (Jonasson, 1991).

The first approach has the learner passively receiving reward and punishments, such as drill and practice, simple response and feedback. The second has students placing new information in long term memory; the learner still passively acquires information from the teacher who presents information in textbooks and lectures. Knowledge is a commodity transmitted from the teacher to the learner. The third approach, learning as knowledge construction, is based on the concept that learners actively construct a knowledge representation in working memory. This emerged in the 1990's based on human learning in realistic settings. The learner is the sense-maker and the teacher is the cognitive guide who provides guidance and modeling on authentic academic tasks. The instructional designer's role is to create environments in which the learner interacts meaningfully and fosters the learner's process of organizing and integrating information.

The goal of Constructivist Learning Environments (Jonassen, 1991) "is to foster problem solving and conceptual development." Objectivist conceptions of learning assume knowledge is individually constructed and socially co-constructed by learners based on interpretations and experiences in the world. The goal is to "engage learners in meaning making (knowledge construction)," (Davidson, 1994) (Wilson, 1998) (Scavery & Duffy, 1996).

2.6.1 Early Pioneers in the Field of Constructivist Learning

In the early 1900's, Piaget's theory of cognitive development in children (Piaget, 1928) postulated a sequence of four qualitatively distinct stages of intellectual development: Sensor-motor, Preoperational, Concrete Operations and Formal Operations. He believed that "the learner must be active; he is not a vessel to be filled with facts...Learning involves the participation of the learner." Creating an environment designed to allow students to explore and independently navigate tendrils of interconnecting concepts will empower and enhance their construction of more cohesive understanding of interconnected facets of a discipline. Later in the 1900's, Vygotsky's (1968) *Zone of Proximal Development (ZPD)* stated that the potential for cognitive development depends on social development. Skills that can be developed in collaboration with peers exceed those which can be attained alone. This supports the hypothesis that gaming can be used to increase social interaction in learning environments and can potentially increase knowledge acquisition. Later in the 1990's, theories based on human learning in realistic settings (Jonassen, 1991) emerged where the learner is the sense-maker and the teacher is the cognitive guide who provides guidance and modeling on authentic academic tasks. The instructional designer's role is to create environments in which the learner interacts meaningfully and fosters the learner's process of organizing and integrating information. The Constructivist Learning Environment provides a framework for designing and building the third approach.

2.6.2 Components of a Constructivist Learning Environment

The Constructivist Learning Environment (CLE) is an education framework that combines eight components to engage students in meaningful learning (Jonassen, 1991) (Dede, 1995). This will be used as a structural framework to model the MMOG learning environment.

The components are:

1) **Active/Manipulative:** Learners are engaged by the learning process in mindful processing of information where they are responsible for the result.

2) **Constructive:** Learners integrate new ideas with prior knowledge in order to make sense or meaning or reconcile a discrepancy, curiosity, or puzzlement.

3) **Collaborative:** Learners naturally work in learning and knowledge building communities, exploiting each other's skills, while providing social support and modeling and observing the contributions of each member.

4) **Reflective/Critical:** Learners should be required by technology-based learning to articulate what they are doing, the decisions they make, the strategies they use and the answers they found.

5) **Complex:** The greatest intellectual error that teachers commit is to oversimplify ideas in order to make them more easily transmittable to learners.

2.6.3 Bruner's Constructivist Theories

A major theme in the theoretical framework of Bruner (1960) is that learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure. Cognitive structure (i.e., schema, mental models) provides meaning and organization to experiences and allows the individual to "go beyond the information given."

As far as instruction is concerned, the instructor should try to encourage students to discover principles by themselves. The instructor and student should engage in an active dialogue (i.e., Socratic learning). The task of the instructor is to translate information to be learned into a format appropriate to the learner's current state of understanding. Curriculum should be organized in a spiral manner so that the student continually builds upon what they have already learned.

Bruner's Theory of Instruction addresses four major aspects:

(1) Predisposition towards learning,

(2) The ways in which a body of knowledge can be structured, so that it can be most readily grasped by the learner,

(3) The most effective sequences in which to present material, and

(4) The nature and pacing of rewards and punishments. Good methods for structuring knowledge should result in simplifying, generating new propositions, and increasing the manipulation of information.

2.6.4 SOI Model

The SOI model (Mayer, 1999) is an individual constructivism approach that is used for designing text-based instructional messages to enable the learners to construct their own meaningful learning outcomes.

S = selecting relevant information

O = organizing information in a meaningful way to the learner

I = integrating the new information with the learner's prior knowledge

The Knowledge and Concept maps have several features in common. First, they organize information in a meaningful way by showing the linkages between concepts. Second, as the knowledge map evolves it integrates and extends the learner's prior knowledge by adding new information.

The SOI model prime suggests that cognitive processes in learners are needed for sense making and to support constructivist learning. It identifies the cognitive processes that foster meaningful learning. Meaningful learning occurs when the learner actively constructs a knowledge representation of information in working memory. Mayer defines constructivist learning as an active learning process in which the learner possesses and uses a variety of cognitive processes.

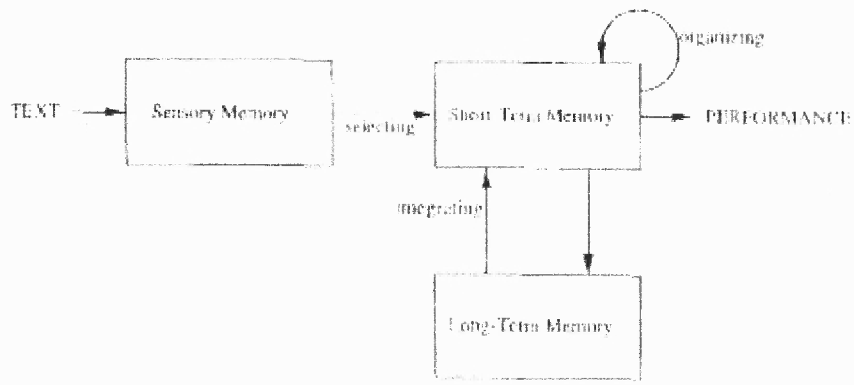


Figure 2.1 SOI model.
Mayer, 1996

2.7 Distributed Learning

“Distributed learning is an instructional model that allows instructor, students, and content to be located in different, non-centralized locations so that instruction and learning occurs independent of time and place,” (Saltsburg & Polyson, 1995). The distributed learning model can be used in combination with traditional classroom-based courses, with traditional distance learning courses, or it can be used to create wholly virtual classrooms.

“A distributed learning environment is a learner-centered approach to education, which integrates a number of technologies to enable opportunities for activities and interaction in both asynchronous and real-time modes” (Bates, 2000).

In a distributed learning environment students gain a greater degree of control of how, when, and where their learning occurs. They also increase their level of responsibility for their own learning and are no longer passive receptacles of information and knowledge.

2.7.1 Advanced Distributed Learning / SCORM

The Advanced Distributed Learning (ADL) initiative was developed for the Department of Defense to harness the power of information technologies to standardize and modernize structured learning. Sharable Content Object Reference Model (SCORM) is a specification of the Advanced Distributed Learning (ADL) Initiative. .

SCORM is a collection of standards and specifications for web-based e-learning. It defines communications between client side content and a host system called the run-time environment. The goal of SCORM is to have a set of technical standards that will allow learning content to interoperate across multiple products, environments and tools, and to make it easier to discover and use such content. In SCORM there is a set of services that launches learning content, keeps track of learner progress, determines in what order (sequence) learning objects are to be delivered, and reports student mastery through a learning experience.

Most web content consists of simple hyperlinks from one page to another. In the SCORM world, the LMS is "smart" and knows what is to be delivered to the learner, when he/she has mastered a skill or competency, and can branch to the right content when needed (e.g., for remediation). Regular web content and servers do not have this capability.

SCORM is divided into four components: reusability, durability, accessibility and interoperability. Reusable refers to content that is independent of learning context. Interoperable is content that will function in multiple applications and environments. Durable refers to content that does not need modification to operate as platforms change. Finally, accessible content can be identified and located when needed. These goals are achieved using shareable content objects (SCO's).

A shared content object is a collection of assets that becomes an independent piece of instructional material. These SCO's should be the smallest unit that can be tracked in a learning system. SCO's cannot directly access other SCO's, therefore, each SCO should stand alone. An SCO can be a lesson, a module or some segment of a course. An SCO must be independent of other SCO's or any other content that gives meaning to it. It is a stand alone object that can integrate into many different courses or forms of instruction.

2.7.2 Asynchronous Learning Environments

2.7.2.1 Introduction. Most traditional synchronous learning environments, primarily face-to-face, rely on the role of the instructor in imparting information. The Constructivist Learning Environment's (CLE) philosophy suggests that learning is a collaborative exercise where the instructor and students work together to form ideas and collectively explore the concepts covered by the course. The asynchronous feature differentiates ALN's that follow many of these CLE attributes where students and teachers can contribute ideas and thoughts at a pace and time of their choosing. "Some of the members take two or three times longer than others to read and respond to materials ... they can work at a time and pace that suits them" (Hiltz, 1994).

Learning, knowledge leading to wisdom, is a process where we stand on the shoulders of our predecessors. There is too much to be learned, even by the most intelligent individuals, to believe we can function and grow on our own. Reading books is one type of asynchronous learning network where ideas are explored with little ability to network with peers. The emergence of online asynchronous learning networks (ALN's) provides the ability to expand peer networks, research larger pools of data and accelerate the rate of group interactions. So, for many, an ALN provides the ability to learn faster and benefit from the collective consciousness.

In addition to the asynchronous advantages of anytime/anywhere learning, additional digital media can provide the ability to combine a vast array of audio, video and interactive tools to enhance the ALN experience.

2.7.2.2 Definition. There are two aspects to the definition of ALN:

1. Asynchronous Learning Networks (ALN's) are defined here as distributed learning environments that are "virtual classrooms" involving asynchronous interaction and the exchange of information exclusively on-line with no face-to-face interaction or conventional physical classroom arrangements. (Hiltz, 1994).

2. "Asynchronous Learning Networks (ALN's) are people networks for anytime and anywhere learning. ALN combines self-study with substantial, rapid, asynchronous interactivity with others. In ALN learners use computer and communications technologies to work with remote learning resources, including coaches and other learners, but without the requirement to be online at the same time," (Hiltz & Goldman, 2005).

2.7.3 Learning Communities

A Learning Community is "a cohesive community where a culture of learning exists in which everyone is involved in a collective effort of understanding," (Bielaczyc & Collins, 1999). A defining characteristic of a Virtual Learning Community (VLC) is that a person or institution must be a contributor of the evolving knowledge base of that group. There is a mutual knowledge building process taking place," (Hunter, 2002).

The asynchronous feature differentiates ALN's from many of the CLE's where students and teachers can contribute ideas and thoughts at a pace and time of their choosing. "Some of the members take two or three times longer than others to read and respond to materials ... they can work at a time and pace that suits them" (Hiltz, 1994). In addition to the asynchronous advantages of anytime/anywhere learning, additional digital media can provide the ability to combine a vast array of audio, video and interactive tools to enhance the ALN experience.

Emergence of a learning community takes time. Not only do participants need to have confidence / trust in their fellow intellectual travelers, but they need to be assured that their thoughts and ideas, no matter how outlandish, are not incorrect by mere attempts at thought experiments trying to test the envelope.

Most important, it is necessary to develop a core database that incorporates the knowledge of a particular discipline. All teachers, for example in Information Systems, would contribute their online materials and an integrated knowledge base would evolve. Student access and frequency of this database should be followed. A true learning community would provide a mechanism for students to explore and share knowledge, and possibly contribute to the core knowledge base, in much the same way that Wikipedia is structured for some subset of the data.

2.8 Review of ALN Papers and Their Relevance to This Research

One of the opportunities and challenges of ALN's is the ability to tailor the learning environment for particular student learning styles so that the user could restructure the presentation environment to facilitate their own particular learning style (see learning styles section below). One approach utilizes Technology Mediated Learning (TML) (Alavi & Leidner, 2001) in which the factors that technology plays in facilitating learning can be discussed. "Technology can influence learning through direct support of the underlying psychological processes, for example facilitating cognitive information processing activities such as search, scanning, transformation, or comparison of information," (Alavi & Leidner, 2001). These features of transforming and comparing information support the Constructivist Learning Environment's philosophy that learning is a collaborative exercise wherein the instructor and students work together to form ideas and collectively explore the concepts covered by the course. The development of an integrated knowledge base, spanning multiple courses, allows students to navigate topics and explore related discipline concepts. This seems to reinforce Alavi and Leidner's assertions as to the potential positive effects on learning that technology can have by facilitating an individual's own learning style.

2.8.1 Learning Styles

Most people prefer some particular method of interacting with, taking in, and processing or information. A learning style is the method of learning particular to an individual that allows that individual to learn best. It has been proposed that teachers should assess the learning styles of their students and adapt their classroom methods to best fit each student's learning style.

One theory (Kolb & Fry, 1975) in this Learning-Style Inventory (LSI) model, is built upon the idea that learning preferences can be described using two continuums: active experimentation-reflective observation and abstract conceptualization-concrete experience. This results in four types of learners: converge (active experimentation-abstract conceptualization), accommodator (active experimentation-concrete experience), assimilator (reflective observation-abstract conceptualization), and diverger (reflective observation-concrete experience). The LSI is designed to determine an individual's learning preference.

One of the most widely known theories of learning style models is that of Dunn and Dunn (1984), a VAK model. This model is widely used in schools in the United States, and numerous articles have been published in peer-reviewed journals referring to this model that "matches students' learning style preferences with complementary instruction to improve academic achievement and student attitudes toward learning," (Dunn, Dunn & Price, 1984). This would seem to indicate that providing the ability for students to customize the method of presentation and content of the knowledge repository would also increase effective learning.

2.8.2Cognitive Styles

Cognitive style is a term used to describe the way individuals think, perceive and remember information. There are a number of cognitive styles that have been hypothesized to affect or enhance learning. One approach, (Hudson, 1996) identified two cognitive styles: convergent thinkers who are good at accumulating material from a variety of sources relevant to a problem's solution, and divergent thinkers who proceed more creatively and subjectively in their approach to problem-solving. This knowledge repository approach has relevance for convergent thinkers, where enhanced modes of learning would be facilitated by aggregating the course materials.

An alternate approach, cognitive complexity theories (Beiri, 1961) identified individuals who are more complex in their approach to problem-solving as opposed to those who are less creative. His approach also involves the organization of constructs and their similarity. If the elements are construed in less related ways for all constructs then there is a more complex organization leading to different results. This approach has also been interpreted by Crockett (1965) and others as one of 'differentiation' and 'integration'. Cognitive complexity is calculated from Crockett's *Role Category Questionnaire* (Crockett, 1965), where the number of independent constructs produced is taken as a measure of cognitive complexity.

Additional tools that can facilitate ALN's are *cooperative work tools* that are defined in terms of their coordination between activities, which implies some domain specific knowledge (Malone & Crowston, 1990). They refer to "goal-relevant relationships" between activities as "interdependencies." These interdependencies may be the key to a possible structure to define interdependent relationships that will be explored in the Knowledge Integration Model. Factors such as identifying goals, mapping goals to activities, selecting actors and selecting activities for actors, would be important for managing interdependencies. This is particularly relevant to defining a core database for a discipline. These interdependencies between concepts need to be mapped and displayed in a user-friendly interface to allow easy navigation of concepts that facilitate knowledge exploration.

2.8.3 Knowledge Elements

"By implementing a singular and global identity of all knowledge elements and other information entities, to allow logical extensibility, the framework for physical extensibility, replication and peer-to-peer interaction, has been established." (Gardner & Sheridan, 2003). In many respects, these knowledge elements seem similar to the shared content objects (SCO's) in SCORM. This article continues by discussing the structure of a knowledge engine; "To create the foundations for a knowledge engine, which embodies at its core the way we group and classify our knowledge of the world through generalization and specialization. These characteristics provide the foundation to deliver a wide variety of solutions in many domains apart from the initial design target of teaching and learning," (Gardner & Sheridan, 2003).

Knowledge sharing tools, not only in educational settings, but in virtual communities in general, could foster faster learning and greater knowledge retention. Most information is presented with relatively little context. Developing the complex interconnections that instill meaning is currently not available or relatively limited. In a paper on knowledge sharing in virtual communities, Bieber et al. (2002) stated that "Properly supported virtual communities could benefit society through collaboration and *knowledge-sharing* in ways not yet articulated. It is believed that the best way to carry out this investigation is through action research, in which an environment of *integrated tools* is introduced and evaluated in an actual virtual community."

"Yet, no existing approaches address the full range of knowledge repositories, and knowledge sharing and learning processes discussed earlier," (Bieber et al. 2002).

A series of new tools has been proposed:

(1) Computer-mediated communication (Turoff et al. 2001),

(2) Conceptual knowledge structures (Bieber et al. 2002) (Turoff et al. 1999),

(3) Advanced hypermedia features (Bieber et al. 1997),

(4) Community process support (Bieber et al. 2002),

(5) Digital video for collaboration, learning, and financial transaction support.

The integration of these components will represent a major advance (Gaines et al. 1997) (Preece, 1999).

2.9 Knowledge Maps

The concept of integrating knowledge maps to organize information was proposed by Bieber (1999). "Using application-oriented conceptual maps to categorize group discussions would be an advancement in the design of computer-mediated communications (CMC) systems to allow much larger groups to collaborate productively. The group meta-communication process should allow the group to modify and evolve these conceptual discourse templates." The voting scales suggested by Bieber suggest the possibility of using voting to weight concept relationships.

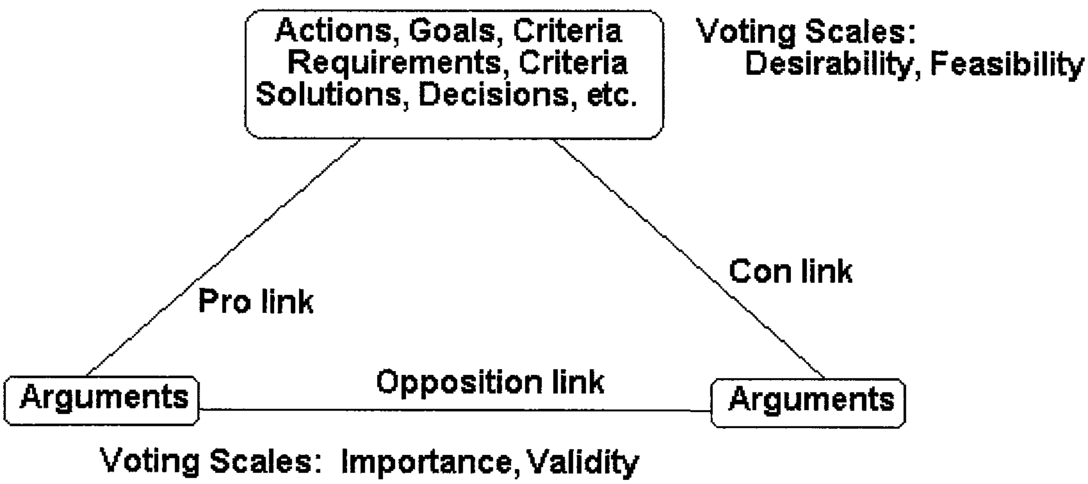


Figure 2.2 Voting scales.
(Bieber, 1999)

In support of this paper's concept, Turoff and Hiltz (1998) proposed "group support tools" for relatively small collaborative groups. They believe that the ability to utilize complex discourse and visualization structures that are tailored to the problem domain can ultimately support problem solving and learning communities of scores to thousands of participants.

One of the key goals is to provide a mapping between ideas and concepts that span an entire discipline. Students and faculty will continually input their ideas, regarding these relationships, which will be represented in the Knowledge Integration Model. These interrelationships will be represented as correlation weights linking concepts. There will be multiple threads that allow possible relationships to be explored by students. These are equivalent to a neural network that allows multiple, possible paths to information retrieval to be explored and new connections to be established. (Mortar, Mohan & Ranka, 1996). Categorizing these relationships between concepts, it is theorized, will enhance knowledge acquisition, "formulating arguments or reorganizing material to introduce new (previously unrecognized) relationships, thereby advancing the knowledge of the participants," (Harasim, 1990).

One of the key features of ALN's is the concept that self learning "can be seen as freeing the individual learner from time and space barriers to two-way communications, which, in supportive situations, can foster *self learning,*" (Keegan, 1986). To enhance this ability of knowledge exploration, tools that facilitate these explorations should result in more knowledgeable students, it is hypothesized. An attempt will be made to confirm these hypotheses by testing students with recognized exams like the Certified Information System Security Professional exams. A number of papers have studied the enhanced learning of ALN'S. "When groups are working asynchronously, members can reflect longer and in more depth about their contributions than when they are in a face-to-face discussion," (Hiltz, 1994). "ALN supported participants, individuals and groups produced better reports than did their manual counterparts," (Ocker, et al. 1995).

If students in collaborative ALN's have better learning outcomes, "The results support the premise that when students are actively involved in collaborative (group) learning on-line, the outcomes can be as good as or better than those for traditional classes." (Hiltz, Coppola, Rotter & Turoff, 2000). It is then reasonable to hypothesize that tools that facilitate collaborative learning, like the new proposed synthesis forum, will further enhance learning outcomes. This is supported by the *Collaborative* CLE principle that states *"learners naturally work in learning and knowledge building communities, exploiting each others skills while providing social support and modeling and observing the contributions of each member."*

Teaching online courses often involves a heavier burden on a professor's time than conventional face-to-face (ftf) courses. This was found to be a factor in faculty's dissatisfaction in teaching online courses (Harman & Davis, 2001). Any mechanism that can relieve this enhanced burden and possibly the isolation of preparing and teaching solitary online courses may enhance faculty satisfaction rates on ALN's. The paper, "Becoming a Virtual Professor" (Coppola, Hiltz & Rotter, 2002) discusses the issues that arise when transitioning to an online ALN mode of teaching. If a centralized knowledge repository was built that was used by multiple courses, it relieves the isolation and heavy load placed on one instructor. A group of instructors working together sharing ideas, skills and responding to students might better distribute the workloads. The discipline databases would be structured initially with one senior ALN professor to mentor the others.

2.10 Distributed Cognition

One of the eventual goals of the knowledge repository is to connect multiple repositories spanning several universities and incorporate/link all knowledge maps into a distributed cognition model. This is supported by the Collaborative CLE principle that "learners naturally work in learning and knowledge building communities, and exploiting each other's skills would provide social support and modeling the contributions of each member."

Distributed cognition is a field of psychology developed by Edwin Hutchins which emphasizes the social effects on cognition. "Traditionally, human cognition has been seen as solely inside a person's head and studies have by and large disregarded the social, physical and artificial surroundings in which cognition takes place." (Salamon, 1993). It suggests that societies and organizations have different ways of learning and organizating information. This implies that learning is a group activity and true learning and knowledge building takes place in a collaborative environment where we share and process information.

Knowledge is distributed among a group's members, each of whom uses his/her knowledge to contribute to the group. "Not only are groups able to accomplish more, but it has been argued that this type of learning leads to deeper understanding of content and processes for the group members." (Di Sessa & Minstrell, 1998).

Why utilize distributed cognition? Because "people think in conjunction and partnership with others and with the help of culturally provided tools and implements." (Salomone, 1993). Cognitive systems that consist of more than one individual have properties that differ from the individuals who participate in them (Hutchins, 1995). For example, individuals, working together on a collaborative task, possess different kinds of knowledge and so will engage in interactions that will allow them to pool the various resources to accomplish their tasks. In addition, individuals in a cognitive system have overlapping and shared access to knowledge that enables them to be aware of what others are doing. This enables the coordination of expectations to emerge, which, in turn, form the basis of coordinated action.

2.10.1 Theories of Distributed Cognition

What distinguishes distributed cognition from other approaches is the commitment to two related theoretical principles. The first concerns the unit of analysis for cognition. The second concerns the mechanisms that participate in cognitive processes. While mainstream cognitive science looks for cognitive events in the manipulation of symbols (Newell, et al. 1989), or more recently, patterns of activation across arrays of processing units (Rumelhart, et al. 1986) (McClelland, et al. 1986) inside individual actors, distributed cognition looks for a broader class of cognitive events and does not expect all such events to be encompassed by the skin or skull of an individual.

2.10.2 Internet Role in Distributed Cognition

The internet could be considered an example of distributed cognition, where meaning is derived and achieved through social interaction among individuals, for example, distributed cognition in which multiple minds are intertwined across time. The distributed cognition approach is concerned with cognitive phenomena that cover a wide spectrum, from analyzing the properties and processes of a system of actors interacting with each other and an array of technological artifacts to perform some activity.

The distributed cognition approach emphasizes the distributed nature of cognitive phenomena across individuals, artifacts and internal and external representations in terms of a common language of 'representational states' and 'media.' In doing this, it dissolves the traditional divisions between the inside/outside boundary of the individual and the culture/cognition distinction that anthropologists and cognitive psychologists have historically created. Instead, it focuses on the interactions between the distributed structures of the phenomenon that is under scrutiny.

The distributed cognition approach involves:

1) The distributed problem-solving that takes place (including the way people work together to solve a problem),

2) The role of verbal and non-verbal behavior (including what is said, what is implied by glances, winks, etc. and what is not said),

3) The various coordinating mechanisms that are used (e.g., rules, procedures),

4) The various ways communication takes place as the collaborative activity progresses, and

5) How knowledge is shared and accessed.

2.11 Concept Mapping Tools

Concept mapping is a technique for visualizing the relationships between different concepts. A concept map is a diagram showing the relationships between concepts. Concepts are connected with labeled arrows, in a downward-branching hierarchical structure. The relationship between concepts is articulated in linking phrases, such as "gives rise to", "results in", "is required by," or "contributes to."

Concept maps are a technique used to visually represent the structure of information. They are a result of Novak's and Gowin's research (1984) of human learning and knowledge representation. "Meaningful learning involves the assimilation of new concepts and propositions into existing cognitive structures." The use of concept maps has been shown to facilitate learning (Coffey, Carnot et al. 2003). Concept maps have also been shown to be of value as a knowledge acquisition tool during the construction of expert systems (Ford et al. 1996) and performance support systems (Coffey, Cañas et al. 2003), and as a means of capturing and sharing experts' knowledge (Coffey et al. 2002).

Cognitive Load Theory {CLT) developed out of several empirical studies of learners as they interacted with instructional materials (Sweller, 1988). He stated that" the optimum learning occurs in humans when the load on working memory is kept to a minimum to best facilitate the changes in long term memory." He found that the format of instructional materials has a direct effect on the performance of the learners using those materials. The concept maps facilitate this retention by showing all the complex links between concepts.

New knowledge gains meaning when it can be related to existing knowledge, rather than being "processed and filed" in isolation according to more or less arbitrary criteria. Concept mapping supports the visualization of such conceptual frameworks and "stimulates prior knowledge by making and requiring the learner to correlate the relationship between concepts," (Jonassen, 1996).

A CLT tool called CMAP, CmapTools is a software environment developed at the Institute for Human and Machine Cognition (IHMC) that empowers users, individually or collaboratively, to represent their knowledge using concept maps, to share them with peers and colleagues, and to publish them. These tools will be explored to see if they can assist in building a shared data repository for this project.

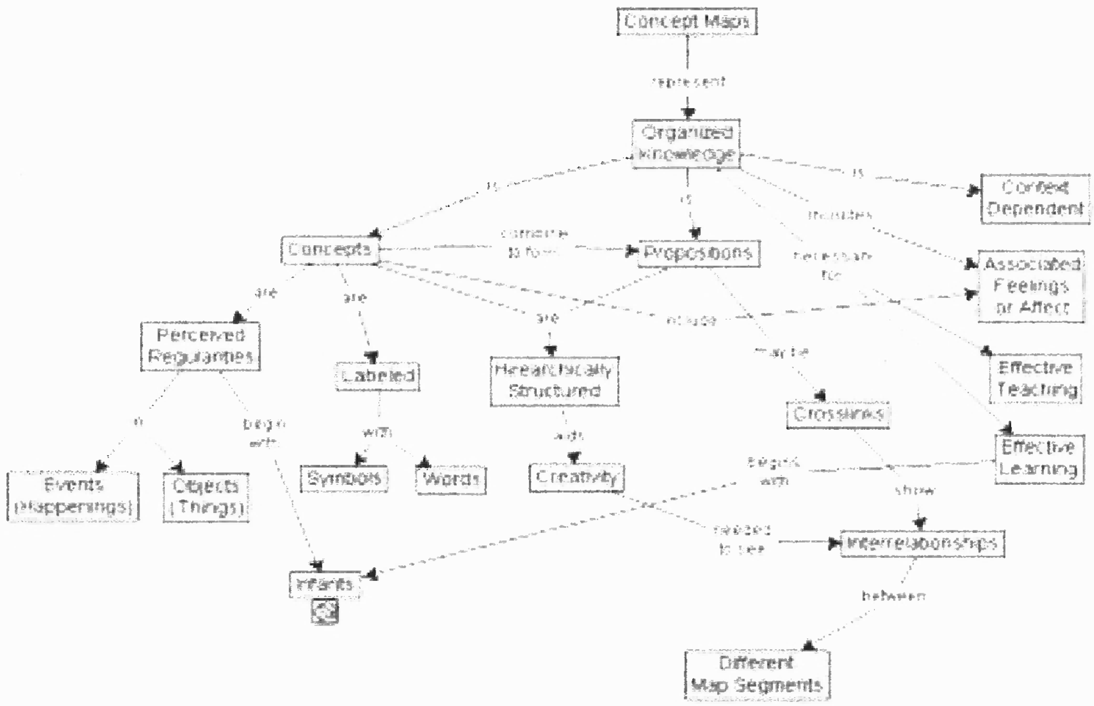


Figure 2.3 Concept mapping tool CMAP.

Knowledge visualization's goal is to facilitate the creation and communication of knowledge through the use of graphic representation techniques. Information visualization concentrates on the use of computer-supported tools to represent large amount of abstract data. knowledge visualization focuses on the transfer or creation of knowledge among people. Concept maps are one way to construct knowledge visualizations.

2.12 Design Science

The following section describes the techniques to define ideas, practices, technical capabilities and products through which the analysis, design, implementation, management and use of information systems can be effectively accomplished. This is referred to as design science.

2.12.1 Design Science in Information System Research

Two distinct and corresponding paradigms, behavioral science and design science, are used in Information System research. The behavioral science model analyzes the efficacy of information systems from the aspect of human perceptions and attitudes. Design science "seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts," (Hevner et al 2004).

> "Design research involves the analysis of the use and performance of designed artifacts to understand, explain and very frequently to improve on the behavior of aspects of Information Systems." (Association for Information Systems (AIS) www.aisnet.org , 2008).

Design science has its roots in engineering and the sciences. It is basically a problem solving model whose goal is to "define ideas, practices, technical capabilities and products through which the analysis, design, implementation and management and use of information systems can be effectively accomplished." (Denning, 1997) (Tsichritzis, 1998). Design science's relevance to IS research is well documented in the literature (Glass, 1999), (Winograd 1996, 1998), (Benbasat & Zmund 1999). "IS research is directly related to its applicability in design, stating that the implications of empirical IS research should be implementable... synthesizing an existing body of research ... or stimulate critical thinking among IS researchers. Technology and behavior are not dichotomous in an information system, they are inseparable," (Lee, 2000).

2.12.2 History of Design Science

Design science research "is an activity that contributes to the understanding of a phenomena," (Kuhn, 1962 and 1996). Design refers to developing and creating something new that is not naturally occurring. Research is an activity that contributes to an understanding of an observable fact. In 1969, Simon established the foundations for 'a science of design,' which would be 'a body of intellectually tough, analytical, empirical, teachable doctrine about the design process.' Simon further decomposes the design process into an inner and outer environment that satisfies certain goals. The outer environment is the set of external forces that act on the object. The inner environment is the components that make up the artifact/object and the relationships with that object to the organization. The interaction of the functionality between the inner and outer environments makes up the design activity.

It has been postulated that there are four general design outputs: constructs, models, methods and instantiations (March & Smith, 1995). Constructs are the language of a problem domain. They arise during the problem conceptualization phase. The model is a set of statements articulating relationships among constructs. A method is an algorithm defining how to accomplish a task. "Implicit in a design research method is the problem and solution statement that is expressed in the construct vocabulary" (March & Smith, 1995). An instantiation is the solution or realization of the artifact in an environment.

Occasionally, the instantiation precedes the complete vocabulary definition as indicated in the iterative evolutionary development of a design.

A complimentary approach to design science (Takeda et al. 1990) is the design of the interface between the inner and outer environment. This is defined as mapping from a functional requirement, constituting a point in multidimensional space, where an artifact, satisfying the mapping, constitutes a point in that space. Design is the knowledge to perform that mapping.

A fifth output of design (Rossi & Stein, 2003), (the first four can be mapped to March and Smith's design methods), is referred to as Better Theories. Design research can contribute to theory building with the first component being methodological construction of an artifact, or experimental proof of a theory. The second, the design of the artifact, can expose relationships between its elements. These relationships can support or refute previously theories. "Human Computer Interfaces (HCI) artifact construction is perhaps the most effective medium for theory development," (Carrol & Kellog, 1989).

The philosophical perspective of the design researcher creates reality through constructive intervention, and then becomes a positivist observer, recording behavior of the system, that is, the testing and experimental process as listed in the design and evaluation phases (Hever et al. 2004).

Table 2.3 Philosophical Research Perspectives

	Positivist	**Interpretive**	**Design**
Ontology	A single reality, knowable, probabilistic	Multiple realities, socially constructed	Multiple, contextually situated alternative world states. Socio-technologically enabled
Epistemology	Objective dispassionate, detached observer of the truth	Subjective values and knowledge emerge from the researcher participant interaction	Knowing through making, objectively constrained construction within a context. Iterative circumspection reveals knowledge
Methodology	Observation, quantitative, statistical	Participation, qualitative, hermeneutical, dialectical	Developmental measure, artifact impacts on the composite system
Axiology (The study of Values)	Truth universal	Understanding situated and descriptive	Control creation progress, improvement, understanding

Design research introduces unique artifacts, which implies that they deal with alternative world states. This contrasts with positivist ontology with a single typical unit of analysis. In design research, even the problem statement is subject to revision as design research proceeds. Epistemologically, a design researcher can determine if a piece of information is factual through means of construction/circumspection. As an artifact is constructed, its behavior and interactions are determined; its meaning is its functionality. The design researcher is thus a pragmatist (Pierce, 1931).

2.12.3 Design Science Guidelines in IS Research

Seven Design Science Research Guidelines have been identified, in the creation of a purposeful artifact (Hevner et al. 2004). An artifact is defined as a vocabulary and symbols. The goal was to develop a framework for effective design science research.

Table 2.4 Design Science Research Guidelines

Design Science Research Guidelines (Hevner et al. 2004)	
Guideline 1: Design as an artifact	Design science must produce a viable artifact in the form of a construct, a model, a method or an instantiation.
Guideline 2: Problem Relevance	The objective of design science research is to develop technology-based solutions to important (business) problems.
Guideline 3: Design Evaluation	The utility, quality and efficacy of a design artifact must be rigorously demonstrated by well executed evaluation methods
Guideline 4: Research Contributions	Effective design science research must provide clear and verifiable solutions in the areas of the design artifact, design foundations and /or design methodologies.
Guideline 5: Research Rigor	Design science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact
Guideline 6: Design as a Search Process	The search for an effective artifact involves utilizing available means to reach desired ends while satisfying laws in the problem environment
Guideline 7: Communication of Research	Design science research must be presented effectively both to technology oriented as well as management oriented audiences

Guideline 3, the Design Evaluation, is further broken down into well-defined evaluation methods. The evaluation of an IT artifact requires metrics and data analysis. It can be evaluated in terms of functionality, completeness, consistency, accuracy, performance, reliability, usability and fit within the organization/context. The design phase is iterative and provides feedback during development. The selection of specific evaluation methods must match the design artifact. Table 2.5 lists available design evaluation methods. The efficacy of the artifact can be demonstrated by the appropriate selection of design evaluation methods (Basilli, 1996) (Zelkowitz and Wallace, 1998).

Table 2.5 Design Evaluation Methods

Design Evaluation Methods (Hevner et al. 2004)	
1. Observational	• Case Study • Field Study
2. Analytical	• Static Analysis • Architectural Analysis • Optimization • Dynamic Analysis
3. Experimental	• Controlled Experiment • Simulation
4. Testing	• Functional Black Box Testing • Structural White Box Testing
5. Descriptive	• Informed Argument • Scenarios

2.13 Semantic Analysis (Semantic Web)

The framework for CUBE will be structured using the *Semantic Web model.* The Semantic Web is a "set of formats and languages that are used to find and analyze data on the web," (Feigenbaum, 2007) (Berners-Lee, 2001). A number of standards, published by the World Wide Web Consortium Semantic Web Activity Initiative, utilize the Resource Description Framework (RDF). Each piece of data, and any link that connects pieces of data, are identified by a unique name called a Universal Resource Identifier (URI). In the RDF scheme, two pieces of information are connected and grouped together in a triplet to infer relationships between concepts.

In 2001 there were approximately a billion web page documents. In 2005, the estimates range from 11.5-19 billion (http://en.wikipedia.org/wiki/Surface_Web). As of 2008, the latest estimate was 30-45 billion publicly available web page documents, (www.Worldwidewebsize.com) a dramatic growth. This excludes private web documents, mostly held by corporations called the invisible web or "deep web" (http://en.wikipedia.org/wiki/Deep_Web), that multiplies this number by 100. With this explosive growth of online content, the need to utilize a semantic web approach to categorizing search information, with an agreed upon ontology that more accurately reflects user intent, especially in technical fields, is more urgent than ever.

An article by Tim Bernards-Lee (2001) stated that the Semantic Web "is a Web of actionable information derived from data through a semantic theory for interpreting the symbols. The semantic theory provides an account of meaning in which the logical connection of terms establishes interoperability between systems and heterogeneous data sets, that originate from distinct communities of scientists in separate subfields. Scientists, researchers, and regulatory authorities in genomics, proteomics, clinical drug trials, and epidemiology all need a way to integrate these components." The meaning described in the article refers to triplets or associations between terms.

The ability to generate complex associations between objects provides the potential to link and grow concepts beyond simple document retrieval. Evolving "concept spaces visually indicates the relationships and important subsets of concepts, particularly subsets that constitute ontological commitments for representing given phenomena. These provide students with large-scale (and even global) views of the structure of concept spaces." (Smith & Lee, 2004). These complex interrelationships can potentially evolve through input from students and faculty for a potentially richer learning environment.

The "semantic web", based on the Resource Description Framework (RDF), provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries. It is a collaborative effort led by the World Wide Web Consortium (W3C), with participation from a large number of researchers and industrial partners.

The semantic web is composed of a set of design principles, including XML, XML Schema, RDF, OWL and SPARQL utilized by a group of experts in a particular field (i.e. World Wide Web Consortium), to create a concept space to facilitate the standardization of terms, relevant to a knowledge domain. These efforts at semantic clarity assist search engines and disciplines to better define and aggregate relationships within a discipline.

2.13.1 Semantic Web Terminology

Knowledge representation is concerned with how people store and process information. In artificial intelligence (AI) the primary aim is to store knowledge so that programs can process it and achieve the approximation of human intelligence. The fundamental goal of knowledge representation (KR) is to represent knowledge in a manner so as to facilitate inferencing (i.e. drawing conclusions) from knowledge. The semantic web is a fusion of notations such as XML, RDF and their interrelationships, to make the output of these KR languages easy for machines to parse and formalize relationships between concepts (Helbig, 2006).

Table 2.6 Semantic Web Terminology

Terms	Acronym	Definitions
FOAF	Friend of a Friend	A popular application of the semantic web is Friend of a Friend (or FOAF), which describes relationships among people and other agents in terms of RDF
OWL	Web Ontology Language	A family of knowledge-representation languages for authoring ontologies. This family of languages is based on two semantics: OWL-DL and OWL-Lite semantics are based on Description Logics, which are a family of knowledge representation languages which can be used to represent the terminological knowledge of an application domain in a structured and formally well-understood way.
RDF	Resource Description Framework :	-A family of World Wide Web Consortium (W3C) specifications originally designed as a metadata model but which has come to be used as a general method of modeling information, through a variety of syntax formats. -The RDF metadata model is based upon the idea of making statements about resources in the form of subject-predicate-object expressions, called "triplets" in RDF terminology. The subject denotes the resource, and the predicate denotes traits or aspects of the resource and expresses a relationship between the subject and the object.
SIMILE	Semantic Interoperability of Metadata and Information in (un)Like Environments	SIMILE is a joint project, conducted by the MIT Libraries and MIT CSAIL, which seeks to enhance interoperability among digital assets, schemata/vocabularies/ontologies, meta data and services.
SIOC	Semantically-Interlinked Online Communities (Breslin, Bojars 2004)	A Semantic Web technology, SIOC provides methods for interconnecting discussion methods such as blogs, forums and mailing lists to each other. It consists of the SIOC ontology, an open-standard machine readable format forexpressing the information contained both explicitly and implicitly in Internet discussion methods, of SIOC metadata producers for a number of popular blogging platforms and content management systems, and of storage and browsing/searching systems for leveraging this SIOC data.
SPARQL	SPARQL Protocol and RDF Query Language	SPARQL allows for a query to consist of triple patterns, conjunctions, disjunctions, and optional patterns.
XML	Extensible Markup Language	A general-purpose markup language, it is classified as an extensible language, any high-level language that allows its user to modify or enrich its syntax, because it allows its users to define their own elements. Its primary purpose is to facilitate the sharing of structured data across different information systems,

CHAPTER 3

HYPOTHESES, MODELS AND KNOWLEDGE REPOSITORY ARCHITECTURE

This chapter describes the research framework used to validate/refute the knowledge repository modeling hypotheses. The first component is a description of the underlying research hypotheses and assessment strategies. The second component introduces two models; The Knowledge Weighting Model (KWM) and the Aggregate Integrate Master model (AIM) that have been postulated to explain the relationships between constructivist constructs and the Integrated Knowledge Repository (IKR). The final component is a detailed description of the (IKR) which has been instantiated in the form of the Constructivist Unifying Baccalaureate Epistemology (CUBE) learning system that forms the construct platform for testing the hypotheses.

3.1 Hypotheses and Assessment Strategies

H1: Students using the Integrated Knowledge Repository (IKR) will have a more positive perception of the learning process than those who use conventional single course teaching paradigms.

H0: There is no relationship between the use of IKR and students' perceptions of the learning process.

Assessment of student perceptions: A questionnaire, "Constructivist Multimedia Learning Environment Survey (CMLES)", will be used to determine students' perceptions of the new system vs. the current paradigm, where courses are presented as single topics/units.

H2: Students utilizing the IKR will develop a more complex understanding of the interconnected nature of the materials linking a discipline than those who take conventional single topic courses.

H0: There is no relationship between the IKR and developing a more complex understanding of the interconnected nature of the materials linking a discipline.

Assessment of unifying knowledge of a discipline: Students were given a case study on a topic that unifies concepts which span multiple courses. They were then asked to solve another problem/case that tests their ability to demonstrate their cross-subject knowledge. A rubric, integrating Jonassen's case analysis rubric, "Learning to Solve Problems" and Hevner's design evaluation methods, "Design Science in IS Research", was used to assess their evolution of skill development using CUBE. A control group of students, who had previous experience with the conventional method of instruction, were given the new case study and rubric to evaluate their comprehension of the course materials.

The categories of the rubric are:

- Quality of information sources cited,
- Constraint analysis,
- Feasibility, and
- Relevance of implications.

Future Research: Hypotheses H3 and H4 will be used to guide future research to refine the implementation of CUBE to maximize its effectiveness

H3: Students will spend more time exploring a concept, using the IKR, which allows them to navigate and construct their own representation, than those using conventional texts.

H0: There is no relationship between use of the CUBE paradigm and increased time spent exploring relationships between concepts.

Assessment of time spent: Students will be given several course topics and record the actual time spent and level of knowledge integration.

H4: Students will be more actively involved in constructing knowledge representations than students in conventional courses.

H0: There is no relationship between use of CUBE and increased knowledge formation.

3.2 Constructivist Learning Principles Referenced By Hypotheses H1 And H2

The Constructivist Learning Principles that relate to Hypotheses H1 and H2 are the following:

- **Active/Manipulative:** Learners are engaged by the learning process in mindful processing of information, where they are responsible for the result.

- **Constructive:** Learners integrate new ideas with prior knowledge in order to make sense or reconcile a discrepancy, curiosity, or puzzlement.
    - Presenting students with information spanning multiple courses, i.e. prior knowledge, they have a greater probability of creating meaning from connections between concepts

- **Collaborative:** Learners naturally work in learning and knowledge building communities, exploiting each others' skills while providing social support and modeling and observing the contributions of each member.
    - The students contribute to the knowledge map, building communities of practice, exploiting the skills of others and building on the skills of others.

- **Conversational:** Learning is inherently a social, dialogical process (Duffy & Cunningham, 1996). That is, given a problem or task, people naturally seek out opinions and ideas from others.
    - Contributions and links in the knowledge map, provided by students, will be evaluated and voted on. This will determine relevance and ranking of concepts; i.e., seeking out the opinions and ideas of others.

- **Reflective/Critical:** Learners should be required by technology-based learning to articulate what they are doing, the decisions they make, the strategies they use, and the answers that they find.
  - The voting will be an iterative process that will evolve over time to refine and critically evaluate decisions they have made.

- **Contextualized:** A great deal of recent research has shown that learning tasks that are situated in some meaningful real world task or simulated in some case-based or problem based learning environment are not only better understood, but also are more consistently transferred to new situations.
  - Case examples will be integrated in the CUBE implementation that reflects the integration of concepts spanning courses.

- **Complex:** The greatest intellectual error that teachers commit is to oversimplify ideas in order to make them more easily transmittable to learners. In addition to stripping ideas out of their normal contexts, ideas are distilled to their simplest form so that students will more readily learn them.
  - The focus of the CUBE system will be to create a learning environment that integrates concepts spanning multiple courses in a discipline, fostering the development of complex skills.

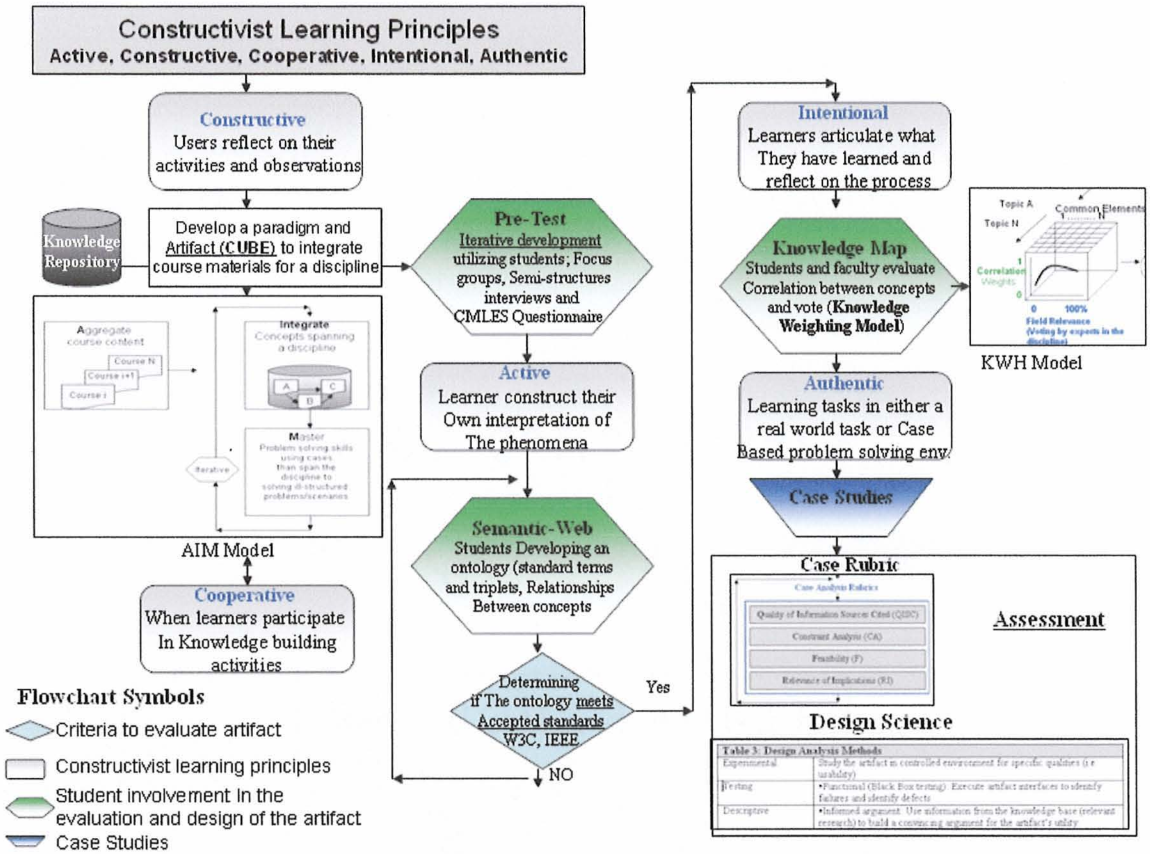


Figure 3.1 Flowchart of key concepts, integrated with the constructivist learning environment.

3.3 Models That Support This Research

Two new models have been introduced to provide a framework for this research. The Knowledge Weighting Model (KWM) provides a quantitative measure of concept relevance.

Building on the Selection-Organization-Integrate (SOI) knowledge construction model, (Mayer, 1996) this research introduces an Aggregate Integrate Master (AIM) model. It provides a framework for representing N number of courses that can be integrated to facilitate conceptual synthesis of concepts.

3.3.1 Knowledge Weighting Model (KWM)

In order to integrate knowledge than spans an entire discipline, there has to be a well defined model to weight the individual course topics/concepts, common elements that exist between the materials, correlation weights as to the interdependence of the variables and finally the evolving relevance of existing and new material to the overall growth of the discipline. (See Figure 3.2) This will evolve over time as new theories appear and the increasing volume of quantitative evidence supporting these claims is presented in refereed journals. One Measure of field relevance could possibly be the number of citations of a particular concept or approach.

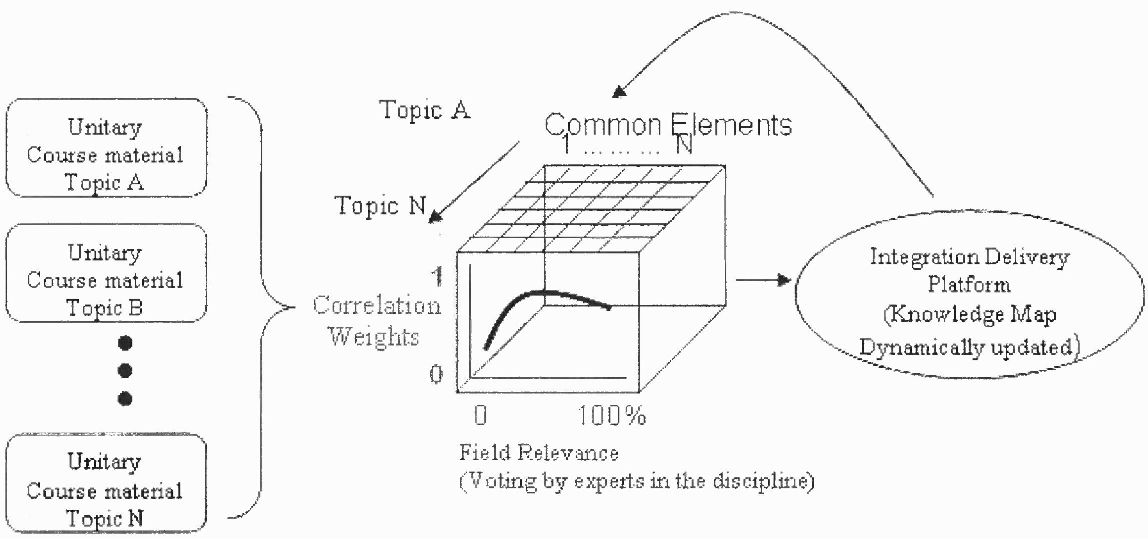


Figure 3.2 Knowledge weighting model.

3.3.1.1 Conceptual Clustering. In order to validate this model, conceptual clustering, a machine learning paradigm for classification, will be utilized. Conceptual clustering uses the inherent structure of the data that drives cluster formation and a description language; it determines classes with common characteristics extracted from large amounts of data. This description language is based on a semantic vocabulary provided by the students. The relationships between semantic terms will be defined by triplets defined in Resource Description Framework (RDF) (World Wide Web Consortium, W3C.org) . Each piece of data and any link that connects pieces of data are identified by a unique name called a Universal Resource Identifier (URI). In the RDF scheme, two pieces of information are connected and grouped together with an operator, predicate, in a triplet to infer relationships between concepts (refer to Appendix).

COBWEB (Fisher 1987, 1995), a hierarchical conceptual clustering algorithm, will be utilized to validate the KWM model. Clustering algorithms normally have difficulty accurately determining clusters that share common attributes. Conceptual clustering, like COBWEB, incorporates attribute definitions that mesh smoothly with a well defined semantic vocabulary.

The correlation weights in the KWM model refer to the voting by students/faculty to determine the importance and relevance of links between terms. These relationships are then clustered together, by similar semantic terms and highest link weights, to form a graphical map that can then be traversed to help students quickly explore related concepts. Each student generates 3-7 links per topic/week per course.

Example: Concepts Weights: Data collected/ Per Course

Links: (10-20 students/course) x (15 weeks/semester) x (3-7 links/topic) ~ 1100

Voting/weights: Students vote on their top choices:

(5 choices/topic)*(15weeks) x (10-20 students)=~1000

Total: Approximately 2100 data points colleted per course

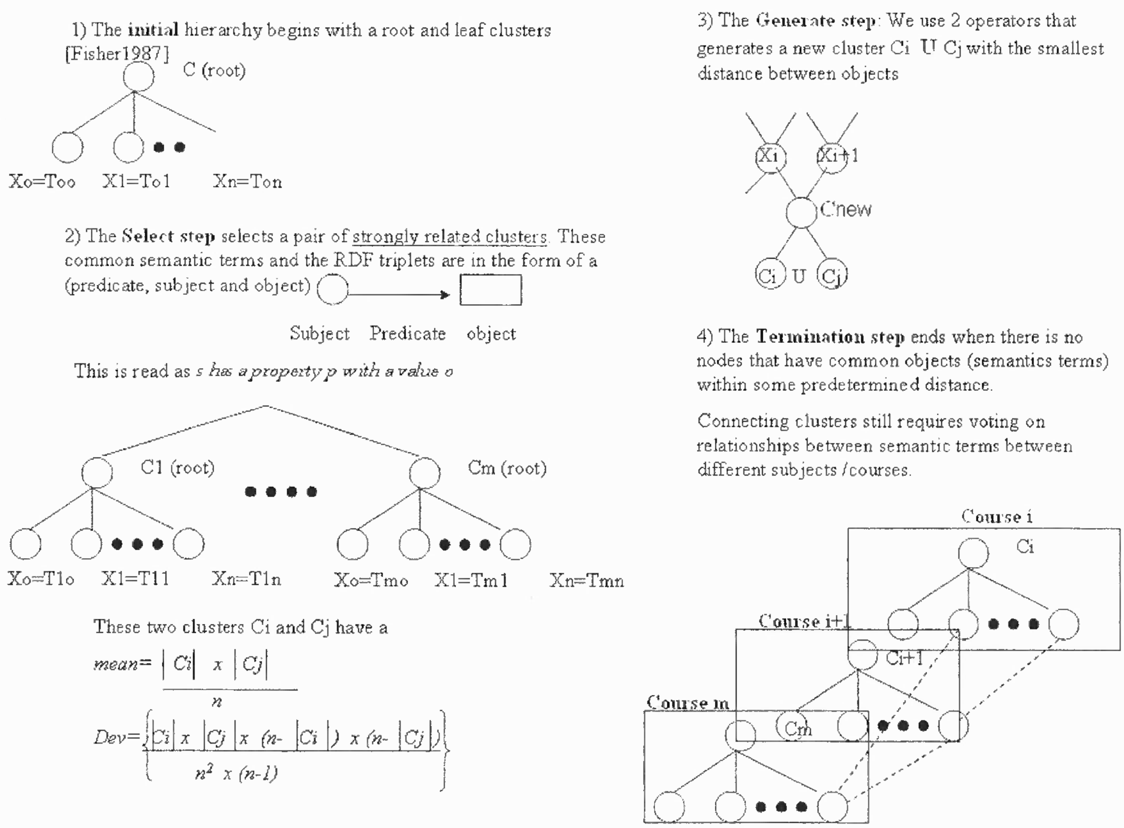


Figure 3.3 Conceptual clustering.

3.3.2 Aggregation-Integration-Master (AIM) Knowledge Construction Model

The Aggregation-Integration-Master (AIM) model builds upon the Selection-Organization-Integrate (SOI) knowledge construction model (Mayer, 1996). The SOI model theorizes that selecting and integrating concepts for a particular course or text, can form the basis for a more dynamic and expansive learning experience model. The Aggregate Integrate Master model, developed as part of this thesis, extends the SOI to a larger domain. It is postulated that effective knowledge integration/comprehension is only truly effective if it correlates all components of a discipline into a cohesive whole.

This is an iterative process where relationships and links between concepts are collectively incorporated by all participants. These weights between concepts, knowledge weighting model, (Figure 3.2), are voted upon and create an evolving concept space. This ensures two essential components. First, the model satisfies the constructivist approach to knowledge formation, where students are the knowledge makers and more effective integration and visualization of meta-cognitive data linking is continually evolving. Second, the knowledge repository continues to evolve integrating new links that ensure the information is timely and relevant.

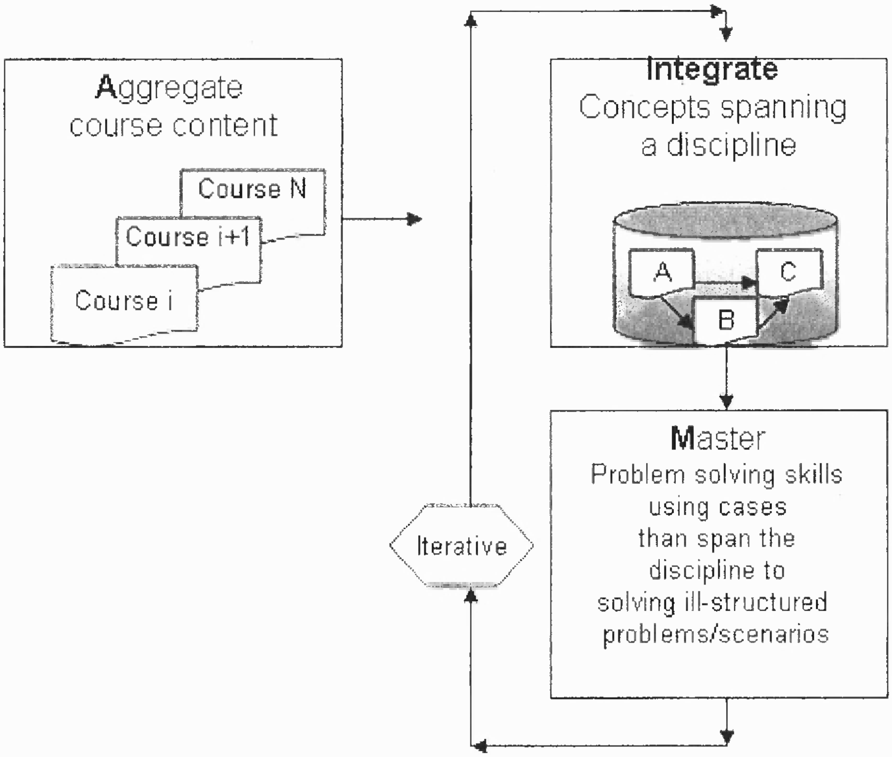


Figure 3.4 AIM knowledge construction model.

3.4 Assessment Methodologies

Students were provided with a tool to add to the knowledge map. These new knowledge relationships/links were available to other students as an alternate/additional path to learn and explore interrelated concepts. Students were measured by a rubric that relates their interest, number of entries, and quality of entries and other students' assessment of the benefit of those other perspectives.

Design science evaluation methods (Hevner et al. 2004) of Observation, Analysis, Experimentation, Testing and Descriptive framework will be used to evaluate the case analysis rubric for H2. The assessment criteria categories (Jonassen, 2003) include:

Quality of Information Sources Cited (QISC), Constraint Analysis (CA), Feasibility (F) and Relevance of Implications (RI), as summarized in Figure 3.4 and Table 3.1.

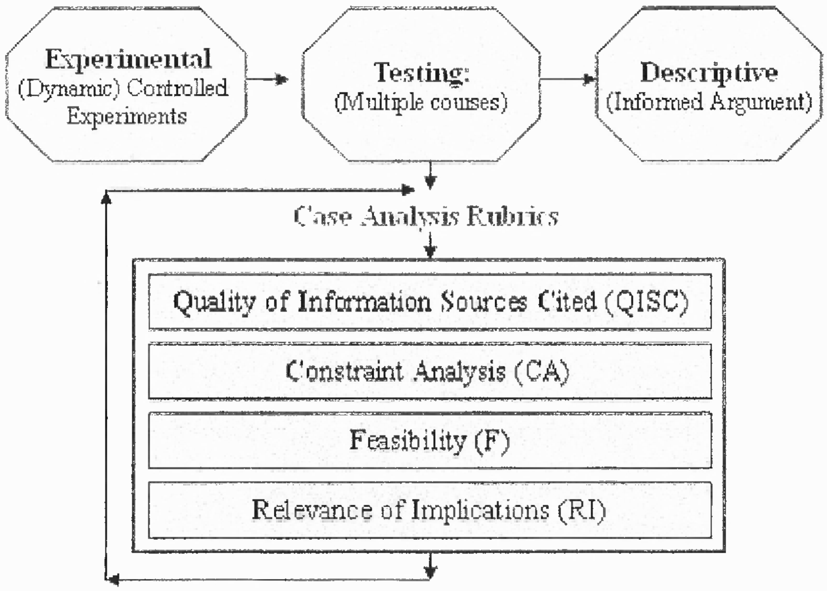


Figure 3.5 Assessment methodology (case analysis rubric) embedded in design science evaluation methods.

"In the Design Science Model, knowledge and understanding of a problem domain and its solution are achieved in the building and the application of the design artifact," (Hevner et al. 2004). Table 3.1 illustrates the utility, quality and efficacy of the design artifact.

Table 3.1 Design Analysis Methods

Design Analysis Methods	
Experimental:	Study the artifact in controlled environment for specific qualities (i.e. usability)
Testing:	•Functional (Black Box testing): Execute artifact interfaces to identify failures and identify defects
Descriptive	•Informed argument: Use information from the knowledge base (relevant research) to build a convincing argument for the artifact's utility.

Case Analysis/System problems are often complex, interdisciplinary problems that originally emerged at Harvard Law School over a hundred years ago (Williams, 1992). These problems engage the learners in understanding and resolving issues, rather than remembering them. It requires learners to critically analyze situations, identify issues and assumptions and engage in reflective ethical thinking (Lundberg, 1999). The levels of learning and thinking engaged by this process are at a much deeper level (Jonassen, 2003).

The system will provide students with a series of cases in the field of Computer Technology. The students' responses will be analyzed using rubrics (Jonassen, 2003) to determine if the Integrated Knowledge Repository approach, to facilitate a more complex understanding of the interrelated nature of the discipline spanning multiple courses, is effective.

Table 3.2 Case Analysis Rubrics

Case Analysis Rubrics	OISC CA F RI
	Sources were internationally recognized; questionable or unknown
Constraint Analysis (CA):	Constraints are all identified; mostly identified or few constraints known
Feasibility (F):	Feasible to implement; unclear if feasible or impossible to implement
Relevance of Implications (RI):	Implications clear and feasible; implications unclear or few implications identified

3.5 Knowledge Repository Design

CUBE: A schema for enhancing learning and knowledge formation.

Acronym: CUBE = (Constructivist Unifying Baccalaureate Epistemology)

Definition: An Integrated Knowledge Repository aggregates course materials of N number of courses with associated concept maps that incorporate constructivist features providing students with the ability to add/construct concept maps.

The first two hypotheses, H1 and H2, will be evaluated to explore the efficacy of the CUBE paradigm. The second two hypotheses, H3 and H4, will be used to guide future research to refine the implementation of CUBE to maximize its effectiveness.

3.5.1 Implementing and Testing the Knowledge Repository

Table 3.3 Knowledge Repository Design

Knowledge Repository Design	
Step 1:	Develop the Knowledge Repository Data Structures
Step 2:	Create the generic design methodology and software that allows professors/Instructors to construct an integrated knowledge repository
Step 3:	Select a discipline to test the design and software
Step 4:	Design the CUBE user interface to facilitate entering course materials; i.e. CUBE surface segmented into 16 fields, representing weekly course topics
Step 5:	Develop concepts maps / visual user interface for navigating information
Step 6:	Test the prototype with a few students and make any needed modifications
Step 7:	Test the knowledge repository with at least 4 classes.
Step 8:	Analyze the data using factor analysis, SPSS and SAS.

3.5.2 Knowledge Repository Test Environment

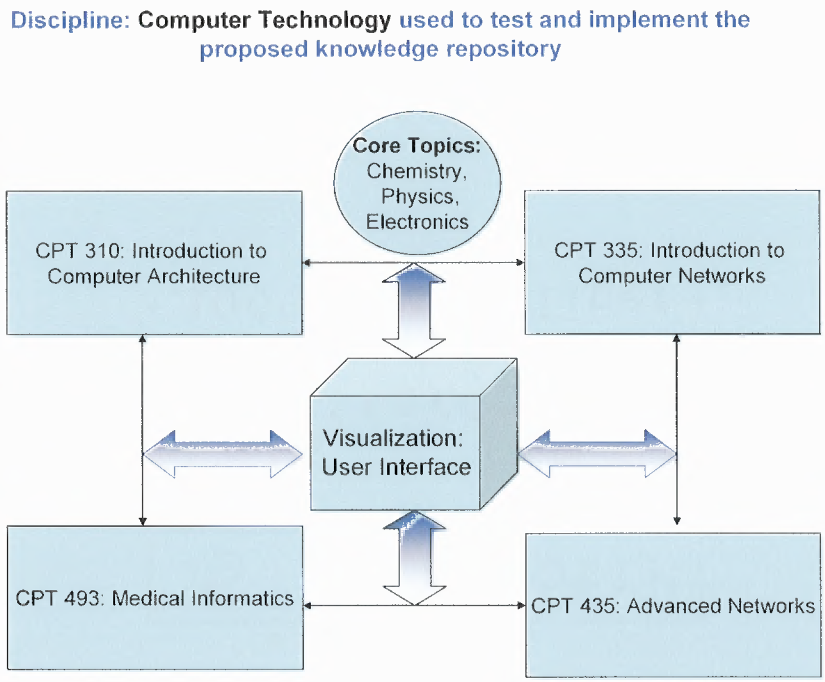


Figure 3.6 Educational test environments.

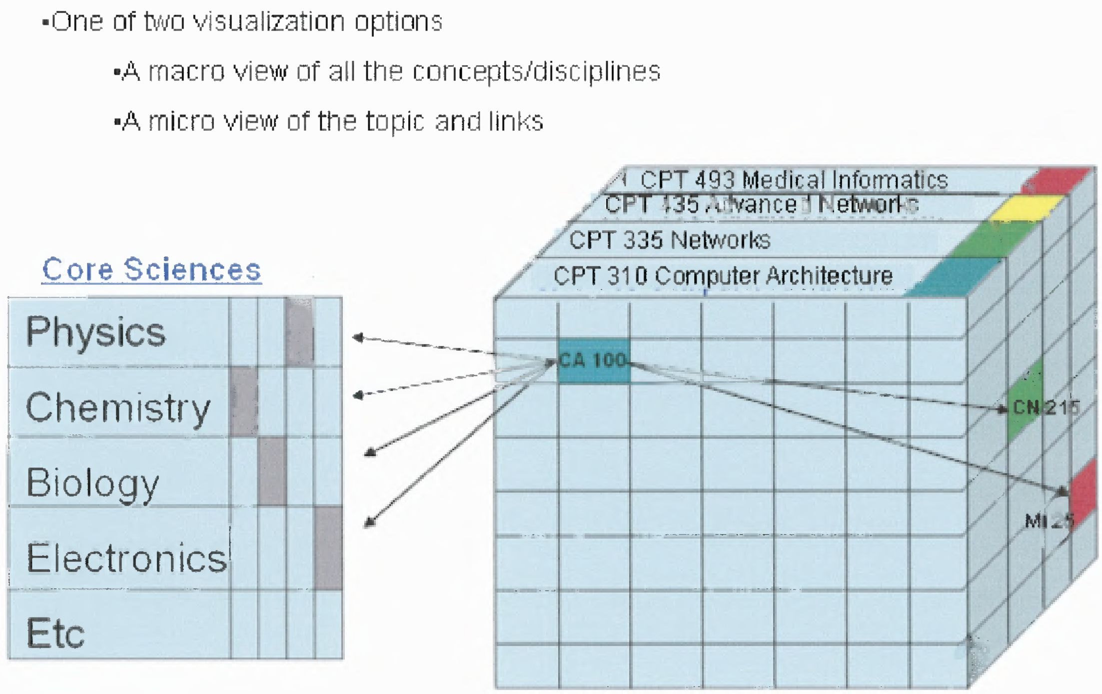


Figure 3.7 Global visualization structure.

3.5.3 Multilevel Information Representation

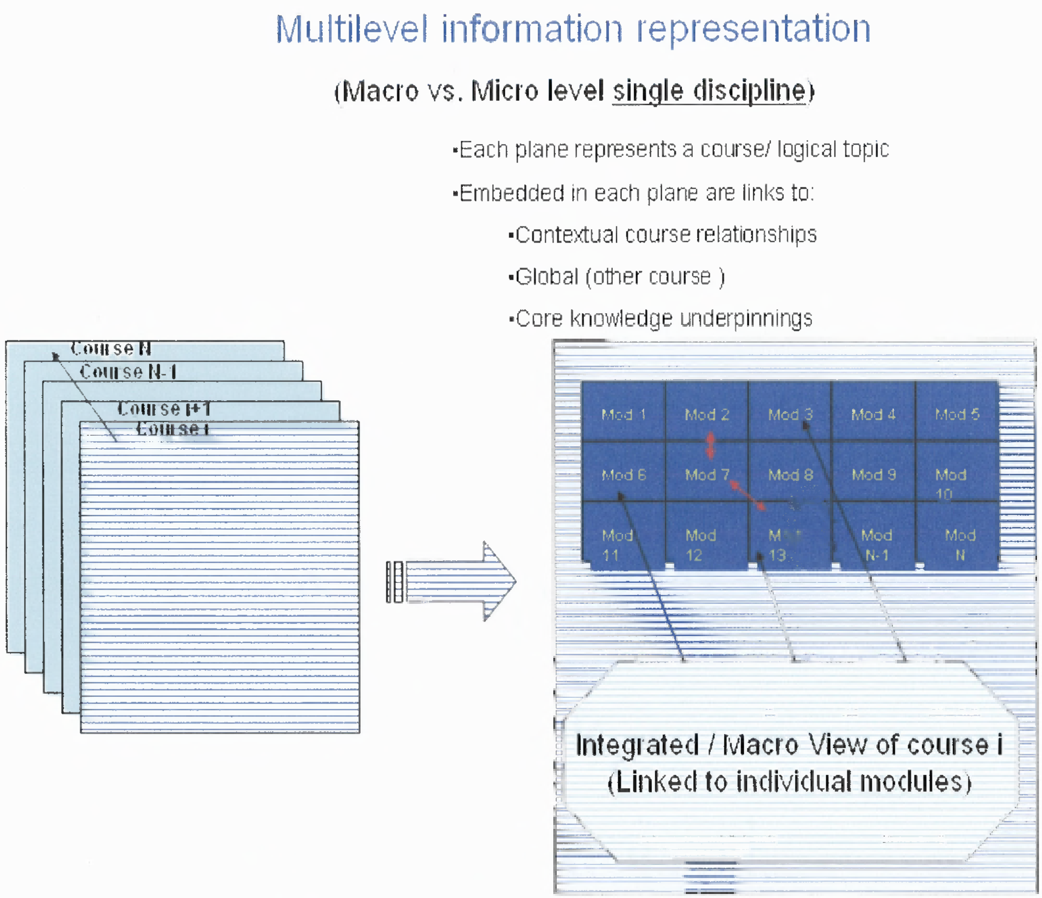
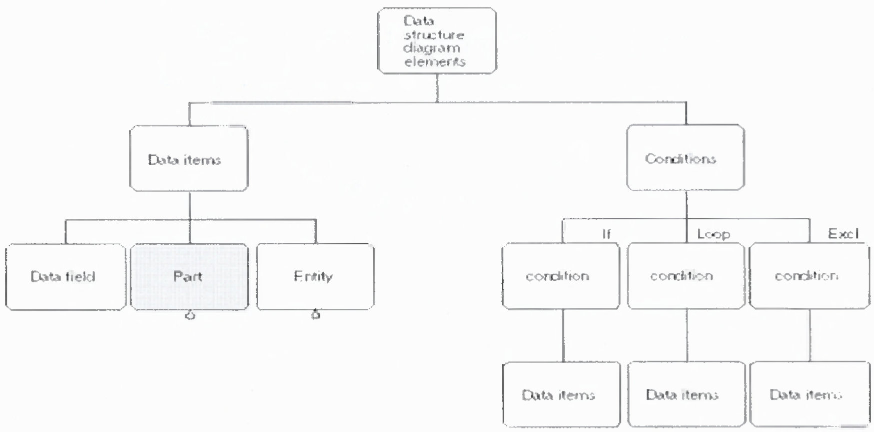


Figure 3.8 Multilevel information representation.

3.5.4 Data Structure Diagrams (Relationships Between Concepts)

Data Structure Diagram (DSD)

- A Data Structure Diagram uses graphical notations for entities, relationships and constraints
  - Entities have a unique representation, and display communication and potential processing of the entity.
  - A relation is a table structure definition (a set of column definitions) along with the data appearing in that structure.
  - A constraint refers to the degree of statistical dependence between or among variables.
- DSDs focus on the relationships of the elements within an entity and enable users to fully see the links and relationships between each entity.



Data Structure Diagram (DSD) (cont.)

Data Structure Diagrams

•A data structure diagram (DSD) is the result of a process of hierarchical decomposition of a complex data area, which is subdivided as far as possible (and reasonable). DSDs are hierarchical tree diagrams depicting "may consist of" relationships between data items if read from top to bottom and following the connecting lines. The boxes in the diagram may represent intermediate complex data items which are further subdivided in the diagram. Fully atomized data items, represented by an attribute which can be directly used as a field definition in a database table.

•References to complex data items detailed elsewhere: Instead of listing attributes, a reference to an entire entity may be made (entities may be depicted by a data structure diagram with only one row of data items - attributes - below the header item). Another possibility to make a reference to several data items is to include a part, i.e. a reference to a separate data structure diagram.

Conditions: The "consists of" relationship may be modified by conditions written in boxes which are marked by an abbreviation on the right hand top of the box defining one of the following conditions:

•"IF": Data items below this box are to be read only if the condition is satisfied

•"EXCL" (= exclusive alternative): Same as "IF", but several such conditions exist which are mutually exclusive

•"LOOP": Data item is repeated as many times as indicated in the condition.

Reference April 29, 1996, wgb@zedat.fu-Berlin.de: W. Berendsohn, University of Berlin)

http://www.bgbm.org/CDEFD/CollectionModel/dsd.htm

Figure 3.9 Data structure diagram.

3.5.5 Data Structure-Pointers

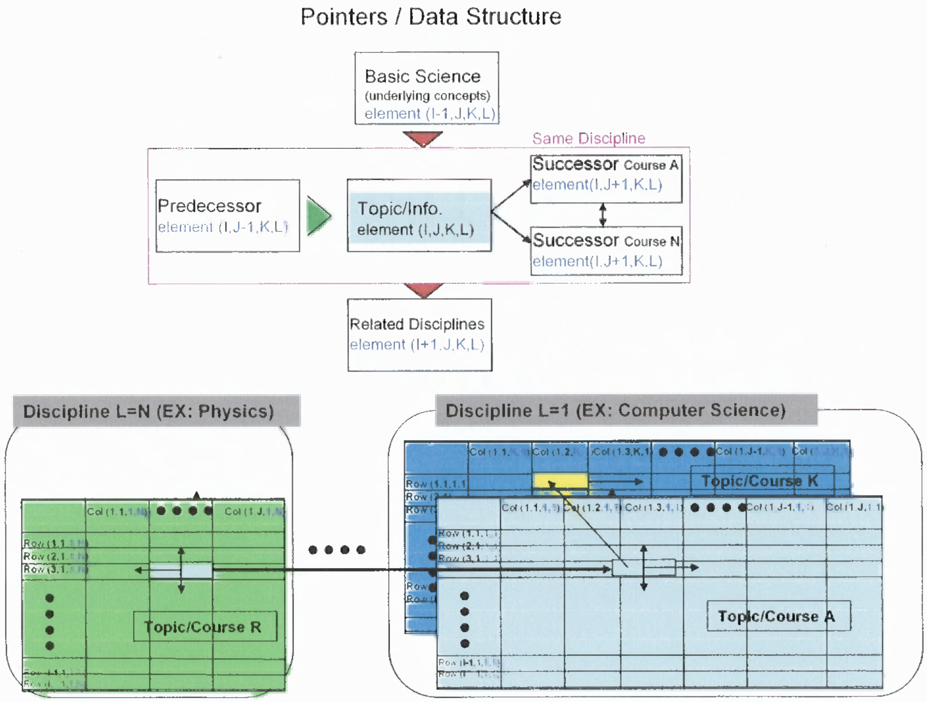


Figure 3.10 Data and pointer structure.

The pointer structure is designed to accommodate course level navigation of topics, the 2D plane element (i,j), discipline level navigation, the 3D table element (i,j,k) and interdisciplinary relationships represented by the 4D element (i,j,k,l). Pointers have multiple successor and predecessor elements. This fourth dimension is essential to accommodate the future growth of the knowledge base. Not only does it connect basic core topics such as math, physics and chemistry that provide the underpinnings of a discipline but it provides possible commonalities between disciplines that are often overlooked.

3.5.6 Message Header Structure

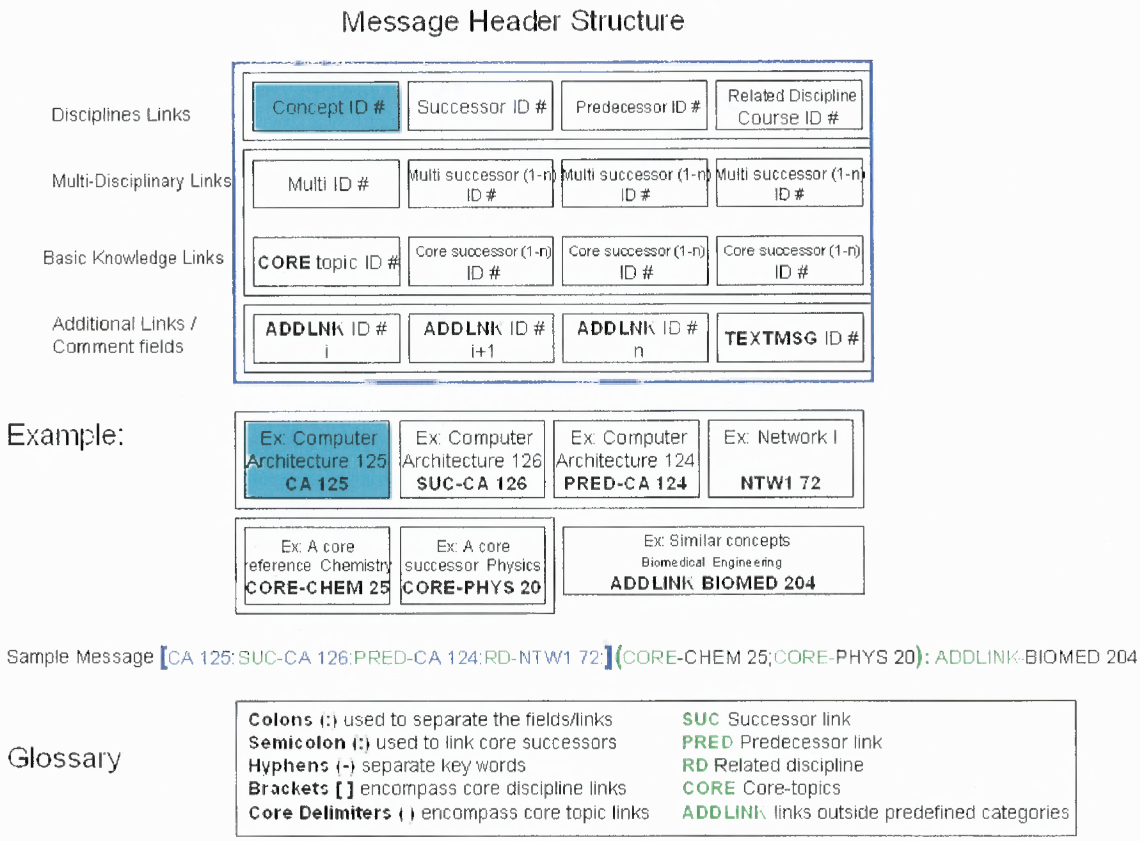


Figure 3.11 Message header structure.

3.5.7 CUBE Software

The CUBE knowledge repository was written using PHP and JavaScript with an Oracle database backend. PHP is a general purpose scripting language used for developing dynamic web content that has embedded support for object oriented programming and PHP data objects. Scripts run directly on the web server, i.e. server-side scripting, which generates dynamic HTML pages. It was chosen since PHP can be deployed on most web servers. Many operating systems and platforms can be used with most relational database management systems and it contains open source libraries to encourage organic growth.

CHAPTER 4

PILOT TESTING

Three methodologies were used to pilot test the CUBE knowledge repository; Semi-structured interviews, focus groups and a questionnaire. The questionnaire has three subcomponents; the Constructivist Multimedia Learning Environment Survey (CMLES), a demographics survey and a set of targeted questions, relating to presentation and content integration of CUBE knowledge repository. Finally, triangulation, the practice of cross-checking findings with multiple data sources, was used to validate the credibility of the instruments.

4.1 Research Population

The population for the study was students in the Bachelors Program in Computer Technology at NJIT. The courses are Computer Architecture, Computer Networks I, Computer Networks II and Medical Informatics. Students received a standard set of instructions that were read from a pre-prepared set of notes to ensure that all students had the same treatment. The students span junior to senior year courses. Since students in the computer technology program start in their junior year, transferring in from other colleges, there was also a unique opportunity to ask additional questions about teaching perspectives, relative to other colleges. Approximately 90 students were available. All Internal Review Board (IRB) requirements were complied with, including offering students alternate assignments for those who chose not to participate.

4.2 Data Collection

An online questionnaire, using the Constructivist Multimedia Learning Environment Survey (CMLES), attached in appendix D, was developed using the Survey Monkey toolkit. Survey Monkey provides a number of rudimentary statistics, such as averages and total response counts. In order to conduct more complex analyses, t-tests, factor analysis etc., export tools embedded in survey monkey were used to export data to SAS 9.1.

4.3 Methodologies Employed

4.3.1 Semi- Structured Interviews

A semi-structured interview is a flexible method of interviewing, allowing new questions to be brought up during the interview, as a result of what the interviewee says. The interviewer, in a semi-structured interview, generally has a framework of themes to be explored, as opposed to a structured interview which has a formalized, limited set of questions.

Unlike the questionnaires, where detailed questions are formulated ahead of time, semi-structured interviewing starts with more general questions or topics. Relevant topics are initially identified and the possible relationship between these topics and the issues form the basis for more specific questions, which do not need to be prepared in advance. The majority of questions are created during the interview, allowing both the interviewer and the person being interviewed the flexibility to probe for details or discuss issues.

4.3.2 Focus Groups

A focus group is a form of qualitative research in which a group of people are asked about their attitude towards a product, service, concept, advertisement, idea, or packaging. Questions are asked in an interactive group setting, where participants are free to talk with other group members.

"Focus groups have a high apparent validity - since the idea is easy to understand, the results are believable. Also, they are low in cost, one can get results relatively quickly, and they can increase the sample size of a report by talking with several people at once," (Marshal, Rossman, 1999).

Types of focus groups:

- **Two-way focus group** - one focus group watches another focus group and discusses the observed interactions and conclusions
-
- **Dual moderator focus group** - one moderator ensures the session progresses smoothly, while another ensures that all the topics are covered
- **Dueling moderator focus group** - two moderators deliberately take opposite sides on the issue under discussion.
- **Respondent moderator focus group** - one or more of the respondents are asked to act as the moderator temporarily.
- **Client participant focus groups** - one or more client representatives participate in the discussion, either covertly or overtly.
- **Mini focus groups** - groups are comprised of 4 or 5 members rather than 8 to 12
- **Teleconference focus groups** - telephone network is used
- **Online focus groups** - computers and internet network is used

4.3.3 Questionnaires

A questionnaire, Constructivist Multimedia Learning Environment Survey (CMLES), was used to determine students' perceptions of the new system vs. the current paradigm where courses are presented as single topics/units. This survey was selected since the CMLES scales demonstrated a high degree of internal consistency reliability (with alpha reliability coefficients ranging from .73 to .82), as well as satisfactory factorial validity and discriminate validity (Maor, 1999).

An additional series of questions were added that explored the basic components of the user interface and the content integration of the knowledge repository. This last section went through a number of iterations and pretest, before the final questionnaire concept was evaluated to validate the instrument.

4.3.4 Triangulation

Once the data was gathered, triangulation, the practice of cross-checking findings with multiple data sources, was used to validate the results. By combining multiple observers, theories, and methods researchers can overcome the weakness or potential biases and the problems that come from single-observer and single-theory studies (Cohen & Manion, 1986).

There are four types of triangulation (Denzin,1970):

1. *Data triangulation*, which entails gathering data through several sampling strategies, so that slices of data at different times and social situations, as well as on a variety of people, are gathered.
2. *Investigator triangulation*, which refers to the use of more than one researcher in the field to gather and interpret data.

3. *Theoretical triangulation*, which refers to the use of more than one theoretical position in interpreting data.

4. *Methodological triangulation*, which refers to the use of more than one method for gathering data.

4.4 Methodology

4.4.1 Method 1: Semi-Structured Interviews

- Semi structured interviews were conducted with students who were currently taking CPT 310 Computer Architecture, that is taught in the conventional single threaded presentation.
- Students were offered alternate assignment options.
- A consent form was signed by the students and they were informed of their rights to withdraw from the research at any time.
- They were then presented with the new tool that integrates the knowledge of their course into a holistic presentation that integrates the course material into the larger view of the discipline as a whole. The tool allows students to navigate conceptual threads linking 4 computer courses.
- The interview was coded and themes and patterns, preferences, dislikes, and design changes were explored.
- A screen shot of the Knowledge Repository tool is in the appendix.

4.4.2 Method 2: Focus Group

- A group of eight students in Computer Technology were engaged in a focus group.
- A round-robin discussion group was utilized to engage all participants in the discussion.
- Two hours were allocated
- Six questions formed the structure of the discussions
- All eight students had laptops and recoded their responses in real time via email. Four of those transcripts are included in Appendix E.

4.5 Pilot Results

4.5.1 Semi-Structured Interviews

In order to evaluate the usefulness and functionality of the Knowledge Repository approach, a group of students was asked a series of questions, listed in Appendix B, which spanned into two classes/sessions. A pretest was administered to evaluate the instrument and subsequently a modified final version of the instrument, incorporating the lessons learned, was developed.

The students were also given a user testing guide, Appendix C, which evolved from its original pretest configuration, to the final test version. The user guide stepped the students through all the basic components of the Knowledge Repository. The tester was available to observe students reactions and provide any assistance if the students had difficulty.

Then, Knowledge Repository topics, as summarized in Table 4.1, were explored. They focused on the user interface, the organization of information, the knowledge map approach to correlating concepts, utilizing the multi-tiered approach described in Bloom's Revised Taxonomy, and finally, the perceived educational benefit of this new paradigm.

Table 4.1 Knowledge Repository Structure

Knowledge Repository Structure	
Characteristics	**Features of the Knowledge Repository**
Interface	Cube presentation: A visual method of organizing and accessing the course content as opposed to the customary one course approach in general use
Organization	Multiple course content format: The philosophical approach of integrating multiple courses into a new teaching paradigm
Knowledge Map	Utilizing Blooms Revised Taxonomy to generate a multi-tiered knowledge structure that is used to correlate concepts over multiple domains
Educational Benefits	Exploring the educational benefits of allowing students to explore conceptual threads linking concepts that span multiple courses: Concept part of the Constructivist learning framework

Pretest Questionnaire:

The pretest questionnaire explored the basic components of the user interface and functionality of the knowledge repository concept. The system functionality was further broken down into the aggregation of multiple course content and knowledge map concept correlation capabilities.

Table 4.2 Pretest Questionnaire

Pretest Questionnaire	
Category	**Questions**
Content (Perceived Usefulness)	1. How would you describe the presentation of multiple courses/content (notes) in one central location? 1a: Do you believe the new system will help you learn the material any better?
	2. How would you judge the benefits of the preview page that shows you a graphical overview of the course content?
User Interface (Perceived Ease of Use)	3. How would you evaluate the screen layout using a cube to represent multiple courses?
	4. How would you describe the user interface: Is it easy to understand how to use the system?
Knowledge Repository	5. What do you think of the “knowledge map” that links ideas across multiple courses (finding how concepts evolve from one course to another)? 5a: What do you think of the 2D version vs. the 3D version? Better or worse? Should you have both?
	6. How would you evaluate the knowledge repository approach of aggregating (combining all the courses notes and links between ideas in one central location (web page)?

Coding Categories:

1. **Perceived Usefulness**
    a. **Presentation of Multiple Course Notes**
        i. Easy
        ii. Undecided
        iii. Difficult
    b. **Preview page (Graphical)**
        i. Easy
        ii. Undecided
        iii. Difficult
    c. **Enhanced Learning**
        i. Beneficial
        ii. Undecided
        iii. Not Beneficial
    d. **Enhanced Understanding**
        i. Beneficial
        ii. Undecided
        iii. Not Beneficial

2. **Perceived Ease of Use**
    a. **Cube interface**
        i. Easy
        ii. Undecided
        iii. Difficult
    b. **General Use Interface**
        i. Easy
        ii. Undecided
        iii. Difficult

3. **Knowledge Repository**
    a. **Knowledge Map linking conceptual threads**
        i. Beneficial
        ii. Undecided
        iii. Not Beneficial
    b. **Knowledge Map helps understand concepts**
        i. Beneficial
        ii. Undecided
        iii. Not Beneficial

Final Questionnaire:

By incorporating the feedback from the initial set of semi-structured interviews, additional questions were added, as high lighted in italics in Table 4.3. These were more in-depth probes. During the initial pretest questions, it was evident that the surface had just been scratched and students felt that more in-depth queries were necessary to explore the full richness of the new system/paradigm. The process involved asking the students "how would you change or improve the instrument?"

Table 4.3 Final Version of Questionnaire

Final Questionnaire *(Italics indicate additions to the pretest questionnaire.)*	
Category	Questions
Content	1. How would you describe the presentation of multiple courses/content (notes) in one central location? 1a: Do you believe the new system will help you learn the material any better?
	2. How would you judge the benefits of the preview page that shows a graphical overview of the course content? *2a: Do you think it helps a student understand what is going on in the course better or worse than the standard text-only course outline?*
User Interface	3. How would you evaluate the screen layout using a cube to represent multiple courses? *3a: Can you think of a better way of representing multiple courses?*
	4. How would you describe the user interface: Is it easy to understand how to use the system? *4a: Is there anything specific you did not like about how the screen is set-up?*
Knowledge Repository	5. What do you think of the "knowledge map" that links ideas across multiple courses (finding how concepts evolve from one course to another)? 5a: What do you think of the 2D version vs. the 3D version? Better or worse? Should you have both? *5b: Do you prefer the 3D version, and maybe larger hiding 2D version?* *5c: What do you think if this knowledge map? Will it help you learn and understand what is going on in the courses? Will it be better or worse?*
	6. How would you evaluate the knowledge repository approach of aggregating (combining all the course notes and links between ideas in one central location (web page)? *6a: Do you think the idea of teaching courses differently, where you have all of the information of multiple courses available to you is a better or worse way of presenting the information?*

Response Summaries:

The following table is a transcript summary of the important points of the semi-structured interviews. Complete transcripts are in the Appendix. A User Guide, also in the Appendix, was followed so that all respondents were asked similar questions.

Table 4.4 Summary of Results from Interviews 1 and 2

Summary of results (detailed) interviews 1 and 2			
Research Areas	**Subtopics**	**Theme**	**Quotes that Support/ conflict**
Perceived Usefulness			Interview 1 = I1 Interview 2 = I2 *(Italics indicates a direct quote)*
	Presentation of Multiple Course Notes		I1: Beneficial: *I think it's very useful to see everything in one central location, because it's very useful to see everything in one place* I2: Beneficial: *The idea is good. Put all of the information into one central database. We can access it any time we want anywhere you are in the world. It's a good way to refresh your memory if you want to go back to a class you have taken year or two years ago. The idea is really good.*
		Enhanced Learning	I2: Undecided: *It all depends on the student*
	Preview page (Graphical)		I1: Beneficial: *I think preview page is just a great way of looking up what the each course is all about for that semester, from the first week of the semester till the fifteenth week of the semester.* I2: Beneficial: *Preview page to me it's a good idea. It shows me a minimal idea of what we cover in each module/week so I can have a better understanding of what we learn.*
		Understand Concepts Better	I1: Beneficial: *Yes, it is very easy to understand how to use the system, knowledge maps really help you as well as 2D and 3D representation of threads help you how to navigate the page as well as the outlines and preview, and looks really good.* I2: Beneficial: *Preview page to me it's a good idea. It shows me a minimal idea of what we cover in each module/week so I can have a better. understanding of what we learn.* *I think the way it's done now it shows multiple layers its goes form layer 1 to layer 2. So it gives more in depth information.*
Perceived Ease of Use			
	Cube interface		I1: Easy: *cubes are a really good way of showing all of the course information listed under each different course name for students to have an easy access to any information they want in a very quick and unique way.* I2: Easy: *The layout I like*
	General Use Interface		I1: Easy:

Table 4.4 Summary of Results from Interviews 1 and 2 (Continued)

Research Areas	Subtopics	Theme	Quotes that Support/ Conflict
Knowledge Repository			
	Knowledge Map linking conceptual threads		I1: Beneficial: *I think it's a good way of showing with the arrows what is important and what is not. And the color coding helps you to decide and then you can easily go back and forth to find out information from any particular course.* I2: Beneficial: *It's a good idea. You have the information in one spot. You don't need to go from site to site because you have all of the information in one central station where everything is there for you*
		2D vs. 3D	I1: Undecided: *I think both versions are a good idea, but 3D has an advantage over 2D, because it shows you a lot clearer, also color coded better then 2D representation.* I2: 3D: *What I would do is to hide the 2D. 3D to me looks much better then 2D.*
	Knowledge Map helps understand concepts		I1: Beneficial: *it is a lot easier, convenient, faster and helpful compared to other computer technology websites that I have seen before. This is an excellent technology website and I hope it'll be very useful to all of computer technology major students.* I2: Beneficial: *It shows what is the most important, how much, what you need to know more then the other classes, so you can get a better understanding of the class.*

4.5.2 Focus Group

A senior project class, CPT 401, held several focus groups that lasted two hours each. This was an iterative process that spanned several months. It comprised seven students, who discussed their impressions of the Knowledge Repository. They were asked to suggest potential improvements of the system and user interfaces. To ensure the group members all focused on the same issues, the web site was projected on a screen. Specific features were highlighted and a script was followed where students responded to each category. A round robin format was utilized to ensure all participants responded to each scripted issue. Notes were taken and the students, who all had laptops, recorded their responses and emailed those real time notes, which are included in Appendix E. Four of the transcripts, which were well structured and followed the focus group outline used during the discussion, are included.

The general perceptions of organizing information spanning multiple courses in a single location and the Knowledge Map were positive. A number of students provided useful feedback on the screen layout that was incorporated into designs used in the final tested system.

Table 4.5 Questions and Responses for the Focus Group

Focus Group: Knowledge Repository (Round Robin Discussion, unedited transcripts in Appendix E)	
Questions	**Responses: Participants are labeled P1, P2, etc.**
1: Thoughts & ideas about designing a Computer Technology web site for NJIT.	**P1: Pros:** the user interface looks very unique compared to other universities computer technology websites. **P2: Cons:** As far as the layout is concerned first I would change the grid background to maybe a more simplified one for it maybe a plain page with the NJIT logo or something related to Computer Technology like a light contrasted circuit board. By expanding the size of the layout, the modules of the webpage could be efficiently utilized and there would be room for expansion. **P3: Suggestions/Enhancements:** A. Lecture notes B. Pre-view C. Video clips D. Place to exchange information between classmates E. Add links to external information F. Links to other classes when additional notes are needed G. A search engine to find the information quicker and more precise to the point we want it. **P4: Suggestions**: I would include all the information pertaining to the courses making it accessible to the user. How I would layout the user interface I'm not sure
2: How would you design a website to integrate all course content for all four years of courses in Computer Technology? (Things you like/dislike/change/Screen layout)	**P1: Pros:** If I were to build this webpage for my BS degree, I would still do something unique like Professor Lubliner is doing. It would really have to be attractive; I would use knowledge maps in order to clear any confusion on the website. **P2:** One thing I do like about the website so far is the fact that all the access that one would need is located on one page. There is no need to roam through various pages to make use of the webpage. **P2: Cons:** One dislike about the site so far is a few of the navigation features such as the 'cube access'. When a second cube is 'outlined', it should automatically retract to its 'home' but instead the user would have to manually press 'back' to retract it **P3: Suggestion-User Interface:** I really would not change a lot on the interface. Maybe what I would change would be to change the course outline, to a more and useful interface. **P4: Pros:** Very easy to use interface well thought out easy to navigate. The pop-up widows for accessing the power point slides works well because of the ability to resize them. You can access multiple power points and have those all displayed at once. **P4: Cons:** I've had a few problems with the site itself the frame sometimes don't seem to be aligned they will shift over and cover other parts of the site. It was fixed simply refreshing the website. It just may be the resolution on my system.

Table 4.5 Questions and Responses for the Focus Group (Continued)

Questions	Responses: Participants are Labeled P1, P2, etc.
3: What do you think about the general concept of integrating course materials for multiple courses in a single website?	**P1: Pros:** You can go into more depth of any course provided within the website. On the select a course column you can click the **Review** button, and open up the power point slide to see all of the modules are listed for that particular course in a semester. It is easy to preview what you will be doing for that course from week one to end within only one page, very convenient and straight forward process. **P2: Pros**: The availability of all the info on this site will greatly benefit a student who is looking for links to all his/her related course work that they have taken (or looking to take) during their time here at NJIT. **P3: Pros:** I personally like the idea of having a review, because I would be able to see what material I will need to know, and what I will learn when I take that class. **P4: Pros:** All the course information being accessible from one place using a very easy to use user interface containing connections from previous and future courses. It would make it easier to study for exams using the knowledge map then being able to use the pop-up widows to open multiple power points.
1. The general screen lay out is good, except some little wording problems I have mentioned before as Review needs to be changed to Preview	**P1: Pros:** Over all the visual set up I like, except the parts I have mentioned I didn't and thought it could be better design. For the course outline display section, you could have a colorful background, maybe a picture and put the writing on top of it with a reasonable coloring. **P2: Cons:** While the UI is structured, some may not find it very user-friendly. I think that just simply zooming in on the page to fit the entire browser window, navigation can be greatly improved. With the larger size the modules on the page can have their own area to distinguish itself. This change will greatly enhance the site with minor changes to the modules.
2. What do you think of the Knowledge Map linking concepts across multiple courses?	**P1:** Connecting things from course to course is important and useful. One information could always relate refer to or could be about information in another course. Information should have links to each other in order for a quick reference. **P3: Pros:** Organizing information into one useful system is great. Since I am paying money for my education I want to have access to everything to help me pass and get my degree. If I don't get something when the teacher explains it I can always go and see the information on the web-site. **P4: Pros:** The course connection features could be one of the best features. As long it functional and easy to understand well thought out and implemented. This feature still not useable but I would like to see this function to give better input.
6: What do you think about linking other multimedia content into the website, such as video clips?	**P1: Pros**: Yes, video clips are very useful to have, where it's necessary on power point slides, I think this is a really good idea since not everyone understands the material verbally, watching the video clips could really be useful and helpful for students to understand the material. **P2: Pros:** The use of video clips is actually a great idea. As far as teaching, it can really help a number of students who aren't able to grasp certain concepts by the use of lecture notes alone. **P3: Pros:** Video clips are really useful in any website. They give another perspective on a particular subject.

4.6 Triangulating Results of the Pilot Study: Qualitative and Quantitative Treatments

Once the qualitative data has been gathered *triangulation*, the practice of cross-checking findings with multiple data sources, is used to validate the credibility of qualitative analyses. The optimum triangulation can be achieved by cross referencing Qualitative and Quantitative data. The Majchrzak, et al. (2000) paper that analyzed computer supported inter-organizational virtual teams was highly regarded due to its depth of data collection and their approach that triangulated qualitative and quantitative results from multiple data points such as: interviews, documentary materials, private interviews etc.

This research has gathered not only qualitative data from multiple sources, semi-structured interviews and a focus group, but has preliminary quantitative data, from a CMLES validated survey, (Table 4.5), that supports most of its original hypotheses, that aggregating courses materials from multiple courses is a preferred method of enhancing students' understanding of the cohesion of information in a discipline.

Table 4.6 CMLES (preliminary) Survey of 24 Computer Technology Students

23. Content Integration	Excellent	very good	good	no opinion	poor	very poor	no positive benefit	Response Count
62. How would you evaluate the knowledge repository approach of aggregating (combining) all the course notes and links between ideas in one central location (web page)?	50.0% (12)	29.2% (7)	16.7% (4)	4.2% (1)	0.0% (0)	0.0% (0)	0.0% (0)	24
63. How would you evaluate the concept of locating all course information/notes for all four years of your college study in one location/web page?	58.3% (14)	29.2% (7)	12.5% (3)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	24
64. Do you think this option, aggregating all course notes on one location, will add to the learning process?	37.5% (9)	50.0% (12)	12.5% (3)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	24
65. What do you think of the "knowledge map" that links ideas accross multiple courses (finding how concepts evolve from one course to another)?	25.0% (6)	54.2% (13)	8.3% (2)	8.3% (2)	0.0% (0)	0.0% (0)	4.2% (1)	24
66. Do you think tht using the knowledge map will help you to learn better?	20.8% (5)	33.3% (8)	37.5% (9)	4.2% (1)	0.0% (0)	4.2% (1)	0.0% (0)	24

A brief summary, (Table 4.7), of CMLES data indicates overwhelmingly that students believe this approach will have positive benefits. Further testing and analysis of learning outcomes will be tested next semester.

Table 4.7 Summary of CMLES Data

Summary of CMLES Data	
Question	**Data combining good, very good and excellent**
Knowledge Repository approach of aggregating course notes	88.2%
Comprehension of interconnected nature of concepts : Using a knowledge Map	91.6%

In summary, students believed in the positive aspects of the approach of providing tools to explore concepts on their own *"You can go into more depth of any course provided within the website [student quote.]"* In addition, the quantitative data from the questionnaire indicated an approximate 90% belief that this approach will be beneficial to their overall learning experiences.

4.7 Constructivist Learning Environment Framework

The design of the integrated knowledge repository began with the selection of the learning paradigm, the Constructivist Learning Environment (CLE), where learners actively construct the interrelationships between concepts.

In order to achieve this aggregation of information, a CUBE prototype was designed and tested with students utilizing four computer technology courses. A semantic web framework, utilizing a common vocabulary, was developed with students' input, to ensure that the concept mapping was consistent and extensible to future expansion. This correlates to the *Active* tenet of the CLE.

The preliminary results of the pilot test supported the CLE tenet that students felt that a learner's active participation in constructing the interrelationships between concepts added to their comprehension of the subject matter by over a ninety percent margin. The second pilot result was that the CUBE system prototype supported their efforts to actively construct this cohesive model of the course content by 88.2% of participants.

4.8 Project Timeline

Table 4.7 indicates the calendar timeline for the project and Table 4.8 indicates the research and testing timeline followed during the course of this research.

Table 4.8 Calendar Timeline for Research Project

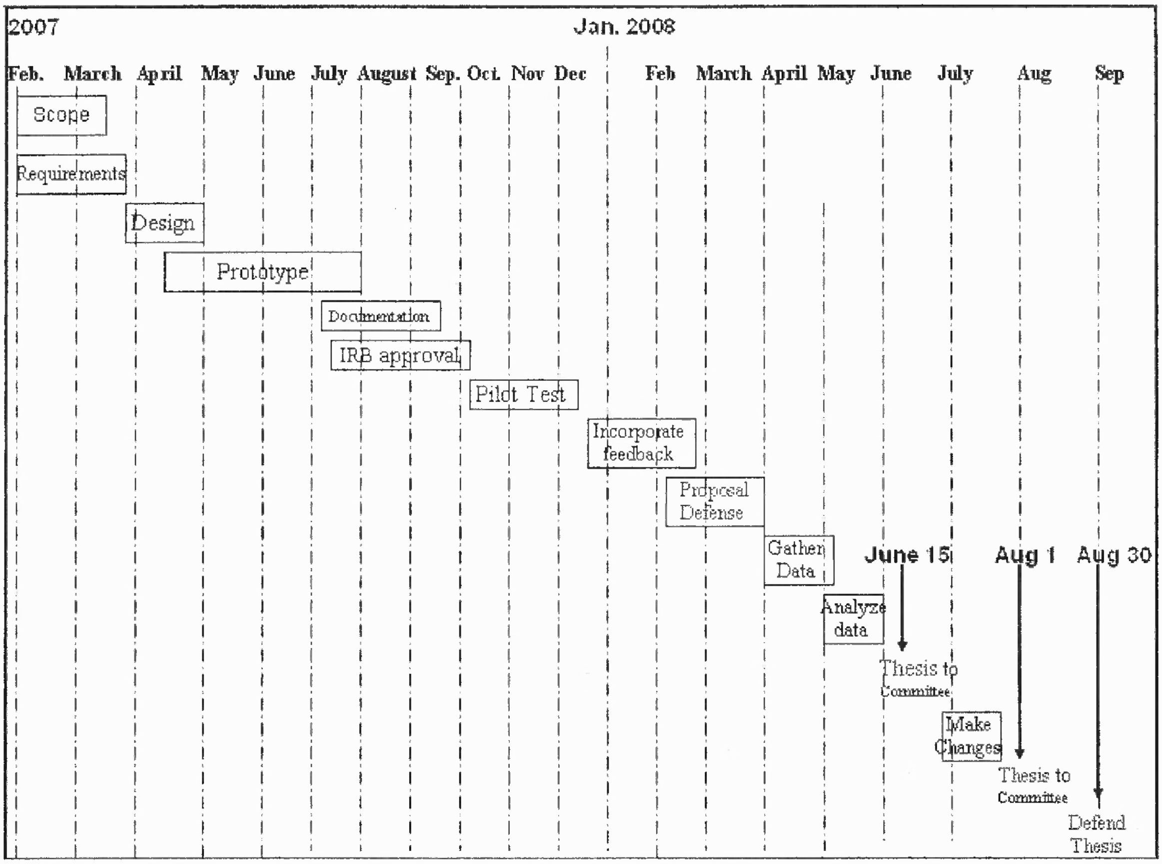


Table 4.9 Project Timeline

ID	Task Name	Work	Duration	Resources	Start	Finish	% Work Complete
1	**Scope**	**360 hrs**	**7 weeks**		**2/1/2007**	**3/24/2007**	**100**
2	Determine project scope	200 hrs	4 weeks	D. Lubliner, Advisors, Students	2/1/2007	3/1/2007	100
3	Determine Resources	40 hrs	1 week	D. Lubliner	3/2/2007	3/9/2007	100
4	Secure Resources	20 hrs	2 weeks	D. Lubliner, NJIT Admin Staff	3/10/2007	3/24/2007	100
5	**Analysis/ Software Requirements**	**255 hrs**	**6.5 weeks**	**D. Lubliner**	**2/1/2007**	**3/26/2007**	**100**
6	Conduct needs analysis	150 hrs	5 weeks	D. Lubliner, Students, Faculty, Advisors	2/1/2007	3/7/2007	100
7	Draft preliminary specifications	40 hrs	1 week	D. Lubliner	3/8/2007	3/15/2007	100
8	Review specifications	15 hrs	2 days	D. Lubliner	3/16/2007	4/30/2007	100
9	**Design**	**210 hrs**	**3.5 weeks**		**3/27/2007**	**4/20/2007**	**100**
8	Develop Specifications	40 hrs	1 week	D. Lubliner, Advisors	3/27/2007	4/3/2007	100
9	Develop initial Prototype	100 hrs	2 weeks	D. Lubliner	4/4/2007	4/18/2007	100
10	Incorporate feedback/ testing	70 hrs	1.5 weeks	D. Lubliner, Students, Faculty	4/19/2007	4/30/2007	100
11	**Develop Prototype**	**350**	**9.5 weeks**		**5/1/2007**	**8/10/2007**	**100%**
12	Identify Modular Code	50 hrs	1.5 weeks	D. Lubliner	5/1/2007	5/15/2007	100 %
13	Develop prototype Code	300 hrs	8 weeks	D. Lubliner	5/15/2007	8/10/2007	100%
14	**Testing**						
15	Develop Test Plans	40 hrs	1 week	D. Lubliner, Advisors	8/11/2007	8/18/2007	100%
15	Unit Testing	80 hrs	2 weeks	D. Lubliner	8/19/2007	9/1/2007	100%
16	Integration Testing	40 hrs	1 week	D. Lubliner	9/2/2007	9/9/2007	100%
17	**Documentation**	**40 hrs**	**1 week**	**D. Lubliner**	**9/10/2007**	**9/17/2007**	**80%**
18	**IRB Approval**	**50 hrs**	**4 weeks**	**D. Lubliner, Advisors, IRB**	**9/10/2007**	**10/10/2007**	**100%**

Parallel

ID	Task Name	Work	Duration	Resources	Start	Finish	% Work Completed
Table 4.8 Project Timeline (Continued)							
19	**Pilot**						
20	Identify test groups	80 hrs	2weeks	D. Lubliner, Advisors	9/18/2007	10/3/2007	100%
21	Develop testing Manual	25	1 week	D. Lubliner, Advisors	10/4/2007	10/11/2007	100%
22	Pilot test	100 hrs	2 weeks	D. Lubliner, Students, Faculty	10/20/2007	11/05/2007	100%
23	Obtain user feedback/ preliminary surveys	20 hrs	1 week	D. Lubliner, Students	11/06/2007	11/13/2007	100%
24	Analyze surveys preliminary statistics	20 hrs	1 week	D. Lubliner	11/14/2007	11/21/2007	100%
25	Incorporate feedback into system/model	40 hrs	1 week	D. Lubliner, Advisors	11/22/2007	11/29/2007	100%
26	**Deployment/ Testing of system**						
24	Determine test groups	40 hrs	1 weeks	D. Lubliner, Advisors	1/22/2008	1/29/2008	90%
25	Proposal Defense	20 Hrs	1 week	D. Lubliner, Committee	3/25/2008	4/1/2008	
26	Testing	75 hrs	3 weeks	D. Lubliner, Students	4/2/2008	4/30/2008	
27	Preliminary analysis data	100 hrs	2 weeks	D. Lubliner, Advisors	4/30/2008	5/14/2008	
28	Send thesis committee	40 hrs	4 weeks	D. Lubliner, Committee	5/15/2008	6/15 2008	
29	Incorporate committees feedback	80 hrs	2 weeks	D. Lubliner	6/15/2007	7/1/2008	
30	Resubmit Thesis to Committee	40 hrs	4 weeks	D. Lubliner, Committee	7/2/2008	8/1/2008	
31	Incorporate any changes	20 hrs	1 weeks	D. Lubliner	8/2/2008	8/9/2009	
32	Defend Dissertation	20 hrs			8/25/2008		

CHAPTER 5

RESEARCH RESULTS

The objective of this chapter is to describe the research that has been completed and to validate/refute the knowledge repository modeling hypotheses.

5.1 QUANTITATIVE DATA

Quantitative research is the systematic scientific investigation of properties and phenomena and their relationships. Quantitative research is often an iterative process whereby evidence is evaluated, theories and hypotheses are refined.

The goal of this phase of the research was to validate hypothesis **H2:** *Students utilizing the IKR will develop a more complex understanding of the interconnected nature of the materials linking a discipline than those who take conventional single topic courses.*

In order to test this hypothesis it was necessary to collect quantifiable data; i.e. an exam (appendix) that covered material spanning multiple courses and then determines if students attained higher scores using the knowledge repository instantiated by the CUBE artifact. To mitigate the possibility of confirmation bias, researcher bias, "a tendency to search for or interpret new information in a way that confirms one's preconceptions and avoids information and interpretations which contradict prior beliefs" [Peter Cathcart Wason 1960], five different faculty from two departments, Electrical Engineering Technology and Computer Technology, administered these exams. In addition to ensure the validly of the results students from multiple majors, at similar points in their education taking conventionally taught courses, were given the exam to establish baseline values from which the efficacy of utilizing the knowledge repository could reliably be determined.

5.1.1 Research Population

Three types of data were colleted. All three groups were given the same questionnaire, in the same order, using the same written instructions to reduce tester bias.

- Baseline data: students majoring in the Electrical and Computer Engineering, ECET, were given the questionnaire as a baseline to determine the skill level of students in courses ranging from their sophomore to senior years. It was determined that students in this related discipline would have similar skills, determined by a similar curriculum, and knowledge in the areas covered by the questionnaire.
    - 37 Electrical and Computer Engineering, ECET, students

- Control group: A control group, Computer Technology students, consists of subjects who have equivalent or similar characteristics as the experimental group at the start of the study. The latter group will receive the treatment or independent variable being investigated while the control group receives a placebo or another treatment. The control group where students, in the same class, who didn't use the CUBE system. The students in the same class were randomly chosen. Half of them used the CUBE system half did not.
    - 19 Computer Technology, CPT, Students

- Treatment Group: Students using the CUBE system were evaluated to test whether the hypotheses could be substantiated.
    - 34 Computer Technology, CPT, Students (treatment group)

Total N (37+19+34) = 90

The quantitative exam, listed in the Appendix, contained ten multiple choice questions. The information tested covered material that spanned the last two years of the Computer Technology curriculum. The questions were specifically designed to evaluate procedural knowledge that required an understanding of the topics tested rather that than rote memory. The results seem to support the contention that the test was sufficiently rigorous since only one student attainted a perfect grade.

Table 5.1 Summary of research population

CUBE System	N **#Students**	Std Dev	Grade (Mean)	Min	Max	Std Error
No (Baseline group) ECET	37	20.68	50.0	0	90	3.40
No (Control Group) CPT	19	17.39	**53.68**	20	80	3.99
Yes (Treatment Group) CPT	21	11.27	**77.14**	40	100	1.93
Yes (Treatment group) Face-to-Face	8	8.345	81.25	70	90	2.95
Yes (Treatment group) Hybrid-E-Learning	5	5.477	86.0	80	90	2.45

5.1.2 Summary of Quantitative Results

- The means of the baseline group was 50.0 and the control group was 53.68. This indicates that there is a similar level of common knowledge that can serve as a baseline comparison of the knowledge repository. The data spans several disciplines; Computer Technology (CPT), Electrical Technology (ECET), Mechanical Engineering Technology (MET), Telecommunications Technology (TMT) and Math (Table 5.1).

- The means of the treatment test scores were (77.14-53.68) or on average **23.46 points higher** for the treatment group, which indicates a clear improvement in test scores utilizing the knowledge repository. The quantitative exam contained ten multiple choice questions so this difference was, on average, two and a half questions difference between groups)

- The Std. Error for the control mean is 3.99 and the STD Error for the treatment mean is 1.93. Since the means are 23.46 units apart, even if each mean is several standard errors away from its true population mean, they would be significantly different from each other.

- These courses were taught by four separate faulty to reduce researcher bias.

- CPT 493 and CPT 493H, Medial Informatics, were both taught using the knowledge repository, with the same instructor spanning two semesters. The 493H class was a hybrid course, 50% face-to-face instruction and 50% was taught using MOODLE in an online format, to evaluate the possible effects of an online environment. The results showed a 4.75 point increase for those students using the hybrid course. This most likely falls within the margin of error of normal exams, but suggests possible future avenues of research. For students who are already comfortable using a web based learning environment the knowledge repository may further amplify the positive learning benefits.

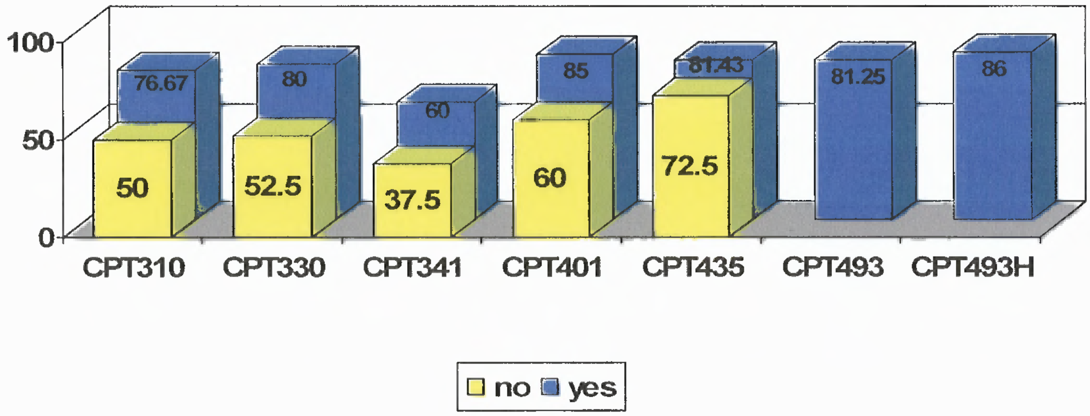


Figure 5.1 Exam performance comparison utilizing CUBE system
(Yes/Blue indicates students' exam grades using the CUBE learning system)

Table 5.2 Distribution of results by course

Analysis Variable : Grade								
CUBETut	Course	N Obs	N	Mean	Std Dev	Minimum	Maximum	Std Error
no	CPT310	5	5	50.00	12.25	30.00	60.00	5.48
	CPT330	4	4	52.50	15.00	40.00	70.00	7.50
	CPT341	4	4	37.50	15.00	20.00	50.00	7.50
	CPT401	2	2	60.00	28.28	40.00	80.00	20.00
	CPT435	4	4	72.50	5.00	70.00	80.00	2.50
yes	CPT310	6	6	76.67	10.33	60.00	90.00	4.22
	CPT330	3	3	80.00	10.00	70.00	90.00	5.77
	CPT341	3	3	60.00	17.32	40.00	70.00	10.00
	CPT401	2	2	85.00	7.07	80.00	90.00	5.00
	CPT435	7	7	81.43	10.69	70.00	100.00	4.04
	CPT493	8	8	81.25	8.35	70.00	90.00	2.95
	CPT493H	5	5	86.00	5.48	80.00	90.00	2.45

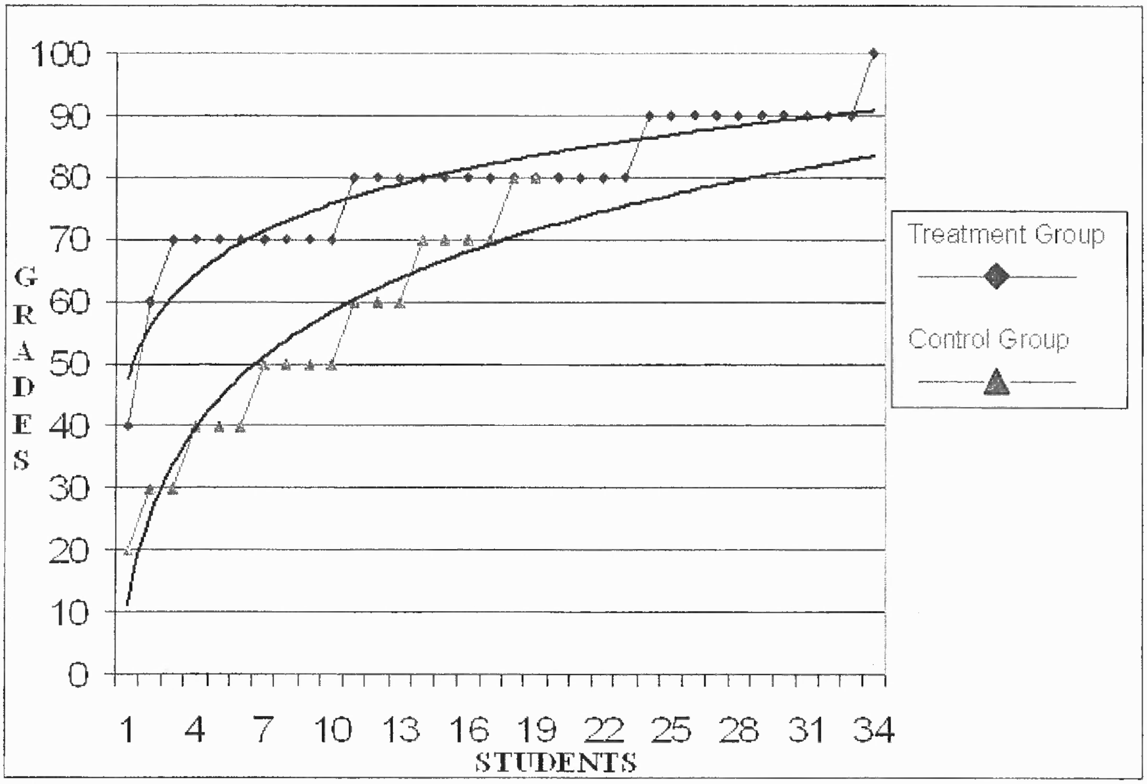


Figure 5.2 Graph of test scores.

The distribution of grades for both the control and treatment groups is evenly distributed, and not biased by outlying data/grades. This supports the concept that the treatment group's results are shifted upward uniformly and are a result of the introduction of the learning environment.

The results are consistent with increased knowledge by students as they progressed through the curriculum. The three hundred level junior courses showed lower initial knowledge comprehension than those of the four hundred level senior courses.

Table 5.3 Distribution of Grades

	CUBETut	Major	Course	Quest_1	QUEST_2	Quest_3	Quest_4	Quest_5	Quest_6	Quest_7	Quest_8	Quest_9	Quest_10	Grade
1	no	met	CPT330	100	internal	dual	speed	load	75	memory	intel	built	million	40
2	no	tmt	CPT330	1000	internal	dual	speed	load	25	have	same	built	billion	60
3	no	is	CPT330	100	internal	pentium	speed	load	25	memory	intel	built	million	40
4	no	ecet	CPT330	1000	internal	dual	speed	load	75	have	intel	lithog	thousand	70
5	yes	cpt	CPT401	1000	external	quad	speed	load	90	data	intel	lithog	billion	80
6	yes	met	CPT341	1000	internal	pentium	speed	load	90	data	intel	lithog	thousand	70
7	no	cpt	CPT341	1000000	external	dual	speed	save	10	data	same	photo	million	20
8	no	cpt	CPT341	1000000	external	pentium	speed	save	50	have	amd	lithog	million	30
9	yes	cpt	CPT341	100	external	pentium	speed	save	90	load	amd	built	billion	40
10	no	cpt	CPT341	1000000	internal	pentium	speed	save	25	have	intel	built	billion	50
11	no	cpt	CPT341	1000000	external	pentium	speed	load	75	have	intel	lithog	million	50
12	no	ecet	CPT435	1000	external	quad	speed	load	90	data	intel	lithog	billion	80
13	yes	cpt	CPT435	1000	external	quad	speed	save	90	have	intel	lithog	billion	80
14	no	cpt	CPT435	1000	external	quad	speed	save	90	memory	intel	lithog	billion	70
15	yes	cpt	CPT435	1000	internal	quad	speed	load	90	have	intel	lithog	billion	100
16	yes	cpt	CPT435	1000	external	quad	speed	load	90	data	intel	lithog	billion	80
17	yes	cpt	CPT435	1000	external	quad	speed	load	90	data	intel	lithog	billion	80
18	no	cpt	CPT435	100	internal	dual	speed	load	75	have	intel	lithog	billion	70
19	yes	cpt	CPT435	1000	external	quad	speed	save	90	data	intel	lithog	billion	70
20	yes	cpt	CPT435	1000	external	quad	speed	save	90	data	intel	lithog	billion	70
21	yes	cs	CPT435	1000	external	quad	speed	load	90	have	intel	lithog	billion	90
22	no	cpt	CPT435	1000	external	pentium	speed	load	90	have	intel	lithog	million	70
23	no	cpt	CPT310	1000	external	quad	speed	load	100	have	same	lithog	million	60
24	yes	cpt	CPT310	1000	external	quad	speed	save	90	have	intel	lithog	billion	80
25	yes	cpt	CPT310	1000	external	quad	speed	load	90	memory	intel	lithog	billion	80
26	yes	tmt	CPT310	1000	external	quad	speed	load	90	data	intel	lithog	billion	80
27	yes	cpt	CPT310	1000	external	quad	speed	save	90	memory	intel	lithog	million	70
28	no	cpt	CPT310	100	internal	dual	speed	save	50	have	same	lithog	billion	50
29	no	math	CPT310	1000000	internal	dual	speed	save	50	memory	amd	robot	billion	30
30	no	cpt	CPT310	1000	internal	quad	speed	save	75	data	amd	photo	billion	50
31	no	cpt	CPT401	1000	external	quad	speed	save	90	have	intel	lithog	billion	80
32	yes	cpt	CPT310	1000	internal	quad	speed	load	90	data	intel	lithog	billion	90
33	yes	civil	CPT310	1000	external	quad	speed	load	90	data	amd	lithog	million	60
34	yes	cpt	CPT493	1000	internal	quad	speed	save	90	have	intel	lithog	billion	90
35	yes	cpt	CPT493	1000	external	quad	speed	save	90	memory	intel	lithog	million	70
36	yes	cpt	CPT493	1000	external	quad	speed	load	75	have	intel	lithog	billion	80
37	yes	cpt	CPT493	1000	internal	quad	speed	load	90	data	intel	lithog	million	80
38	yes	cpt	CPT493	1000	external	quad	speed	save	90	have	intel	lithog	billion	80
39	yes	cpt	CPT493	1000	external	quad	speed	load	90	have	intel	lithog	billion	90
40	yes	cpt	CPT493	1000	external	quad	speed	save	90	memory	intel	lithog	billion	70
41	yes	cpt	CPT493	1000	external	quad	speed	load	90	have	intel	lithog	billion	90
42	yes	cpt	CPT401	1000	internal	quad	speed	load	90	data	intel	lithog	billion	90
43	no	cpt	CPT401	100	internal	pentium	speed	save	25	memory	intel	lithog	million	40
44	yes	cpt	CPT330	1000	external	quad	speed	load	90	data	intel	lithog	billion	80
45	yes	cpt	CPT330	1000	external	quad	speed	load	90	have	intel	lithog	billion	90
46	yes	tmt	CPT330	1000	external	quad	speed	load	90	memory	same	lithog	billion	70
47	no	tmt	CPT310	100	internal	pentium	speed	load	25	have	intel	lithog	billion	60
48	yes	cpt	CPT341	1000	external	pentium	speed	save	90	have	intel	lithog	billion	70
49	yes	cpt	CPT493H	1000	external	quad	speed	load	90	have	intel	lithog	billion	90
50	yes	cpt	CPT493H	1000	external	quad	speed	save	90	have	intel	lithog	billion	80
51	yes	cpt	CPT493H	1000	internal	quad	speed	load	90	have	amd	lithog	million	80
52	yes	cpt	CPT493H	1000	external	quad	speed	load	90	have	intel	lithog	billion	90
53	yes	cpt	CPT493H	1000	external	quad	speed	load	90	have	intel	lithog	billion	90

Questionnaire data is displayed in Tables 5.3 and 5.4 for the Control and Treatment groups. "No" indicates the control group and "yes" indicates the treatment group.

Table 5.4 Questionnaire Data for Baseline Group

	CUBETut	Major	Course	Quest_1	Quest_2	Quest_3	Quest_4	Quest_5	Quest_6	Quest_7	Quest_8	Quest_9	Quest_10	Grade
1	no	ecet	ECET215	1000	external	quad	speed	save	25	memory	intel	lithog	thousnad	50
2	no	ecet	ECET215	1000	internal	quad	speed	load	25	memory	amd	lithog	billion	70
3	no	ecet	ECET215	1000	internal	quad	speed	save	50	have	amd	built	billion	60
4	no	ecet	ECET215	100	internal	dual	speed	save	50	memory	amd	lithog	thousand	30
5	no	ecet	ECET215	1000	internal	quad	speed	save	75	have	amd	lithog	million	60
6	no	ecet	ECET215	1000	internal	quad	speed	save	75	have	intel	lithog	billion	80
7	no	ecet	ECET215	1000	internal	dual	speed	load	25	have	same	lithog	billion	70
8	no	ecet	ECET215	1000	external	quad	speed	save	50	data	amd	built	billion	40
9	no	ecet	ECET215	1000	neither	pentium	speed	save	75	data	intel	lithog	million	40
10	no	ecet	ECET215	1000000	neither	dual	neither	save	90	data	same	built	million	10
11	no	ecet	ECET215	1000	neither	dual	speed	save	75	memory	amd	lithog	million	30
12	no	ecet	ECET215	1000000	internal	quad	speed	load	75	data	intel	lithog	million	60
13	no	ecet	ECET410	1000	internal	dual	extra	load	100	data	same	robots	million	30
14	no	ecet	ECET410	1000	internal	dual	extra	load	100	memory	amd	built	billion	40
15	no	ecet	ECET410	1000	internal	dual	neither	save	75	memory	intel	lithog	million	40
16	no	ecet	ECET410	1000000	internal	pentium	speed	save	90	have	intel	built	billion	60
17	no	ecet	ECET410	1000	internal	quad	neither	save	50	have	amd	built	thousand	40
18	no	ecet	ECET410	1000	internal	pentium	speed	save	50	data	amd	lithog	thousand	40
19	no	ecet	ECET410	1000	internal	quad	speed	save	50	have	same	lithog	million	60
20	no	ecet	ECET410	1000	internal	dual	speed	save	25	data	amd	built	million	30
21	no	ecet	ECET410	1000	internal	dual	speed	load	50	have	intel	lithog	million	70
22	no	ecet	ECET410	1000	internal	quad	speed	load	90	have	intel	lithog	million	90
23	no	ecet	ECET410	1000	internal	quad	speed	load	90	have	amd	lithog	million	80
24	no	ecet	ECET410	100	neither	dual	speed	load	25	have	same	built	million	30
25	no	ecet	ECET410	1000	internal	dual	speed	load	75	have	load	intel	million	70
26	no	ecet	ECET410	1000	internal	dual	speed	load	75	have	same	lithog	million	60
27	no	ecet	ECET410	1000	internal	quad	speed	save	75	have	same	lithog	million	60
28	no	ecet	ECET401	100	external	quad	speed	save	75	have	same	lithog	million	40
29	no	ecet	ECET401	1000	internal	quad	speed	load	50	memory	same	built	million	60
30	no	ecet	ECET401	1000	internal	quad	speed	load	75	memory	same	lithog	million	60
31	no	ecet	ECET401	1000	internal	dual	speed	load	75	have	intel	built	million	60
32	no	ecet	ECET401	1000000	neither	pentium	neither	save	75	have	amd	lithog	million	20
33	no	ecet	ECET401	1000000	external	pentium	neither	save	75	memory	same	built	million	0
34	no	ecet	ECET401	1000	internal	quad	speed	save	90	memory	amd	lithog	billion	70
35	no	ecet	ECET401	1000	internal	pentium	memory	save	50	have	intel	lithog	thousand	50
36	no	ecet	ECET401	1000	internal	pentium	neither	save	25	memory	same	built	million	20
37	no	ecet	ECET401	1000	internal	quad	speed	load	100	data	intel	lithog	billion	70

Table 5.5A Baseline Group Distribution

Analysis Variable : Grade								
CUBETut	Course	N Obs	N	Mean	Std Dev	Minimum	Maximum	Std Error
no	ECET215	12	12	50.00	20.45	10.00	80.00	5.90
	ECET401	10	10	45.00	24.15	0.00	70.00	7.64
	ECET410	15	15	53.33	19.15	30.00	90.00	4.94

Table 5.5 B Baseline Group Distribution

Analysis Variable : Grade							
CUBETut	N Obs	N	Mean	Std Dev	Minimum	Maximum	Std Error
no	37	37	50.00	20.68	0.00	90.00	3.40

5.1.3: Data Analysis: (Quantitative Data)

T-tests:

- Students were assigned randomly to the treatment or control group and then the variable grades were measured, that were hypothesized to be affected by the treatment.

- To determine whether the means of the treatment and control group are significantly different, the null hypothesis (Ho) states that the treatment and control groups would have the same mean, if we repeated the experiment a large number of times, and that the differences are attributable to the luck of the draw.

- The alternative hypothesis (H2) to the null hypothesis is that one mean will be greater than the other, a one tailed test, or will be different.

- The t-test is used to determine that the probability that the difference in means that is observed is due to chance. The lower the likelihood that the difference is due to chance, the greater the likelihood that the difference is due to there being a real difference in treatment and control.

Table 5.6 The t-test Procedure Results

The TTEST Procedure

Statistics												
Variable	CUBETut	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev	Std Dev	Upper CL Std Dev	Std Err	Minimum	Maximum
Grade	no	19	45.304	53.684	62.065	13.139	17.388	25.714	3.9891	20	80
Grade	yes	21	71.359	77.143	82.926	9.7204	12.705	18.348	2.7726	40	100
Grade	Diff (1-2)		-33.14	-23.46	-13.78	12.345	15.105	19.468	4.7828		

T-Tests					
Variable	Method	Variances	DF	t Value	Pr > |t|
Grade	Pooled	Equal	38	-4.90	<.0001
Grade	Satterthwaite	Unequal	32.7	-4.83	<.0001

Equality of Variances					
Variable	Method	Num DF	Den DF	F Value	Pr > F
Grade	Folded F	18	20	1.87	0.1762

- The Equality of Variances gives us the probability that the variances are unequal due to chance.
  - The T-Test values are <.0001 so we reject the null hypothesis (H0) that the variances are equal.
  - The F ratio (F value larger variance/smaller variance) is 1.87. i.e. the probability of by chance alone a ratio this large or larger is 0.1762.
  - That is, if the two samples came from populations with equal variance, there is a small probability (0.1762) of obtaining a ratio of variances of 1.87 or larger by chance. So we can decide to use the t-value appropriate for groups with unequal variance.

5.2 Qualitative Data

Qualitative research involves an in-depth understanding of human behavior and the reasons that govern human behavior. It investigates the why and how of decision making, as compared to what, where, and when of quantitative research

The qualitative data, gathered from the CMLES survey with additional demographic questions and CUBE related questions, were used to test hypothesis H1.

H1: Students using the Integrated Knowledge Repository (IKR) will have a more positive perception of the learning process than those who use conventional single course teaching paradigms.

H0: There is no relationship between the use of IKR and student interest

Assessment of student perceptions: A questionnaire, Constructivist Multimedia Learning Environment Survey (CMLES), will be used to determine students' perceptions of the new system vs. the current paradigm, where courses are presented as single topics/units.

This survey was selected since the CMLES scales demonstrated a high degree of internal consistency reliability (with alpha reliability coefficients ranging from .73 to .82), as well as satisfactory factorial validity and discriminate validity (Maor, D. 1999). The Maor paper supports the reliability and validity of the CMLES for assessing students' and teachers' perceptions as one important aspect in evaluating learning environments which promote the use of multimedia programs and constructivist learning approaches.

5.2.1 Factor Analysis

To validate Maor's findings, the following principal components factor analysis, followed by varimax rotation was computed on the CMLES Questionnaire data gathered in this research study. (See Table 5.7) The results are consistent with Maor's 1999 and 2005 papers' findings, that the CMLES questionnaire demonstrated a high degree of internal consistency reliability with alpha reliability coefficients that ranged from .82 to .93.

Alpha coefficient ranges from 0 to 1 may be used to describe the reliability of factors extracted from dichotomous (questions with two possible answers) and multi-point questionnaires (i.e., rating scales: 1 -5). The higher the score, the more reliable the generated scale. A value of 0.7 or higher is an acceptable reliability coefficient (Cronbach, 1951), (Nunnaly, 1978). In our findings, the alpha coefficients were in the range of .82 to .93 indicating a high reliability of the factors (See Table 5.7 and data analysis in the Appendix).

Table 5.7 Principle Components Factor Analysis on CMLES Questionnaire: CUBE

Factor Loading (for Current [Actual] and Ideal [Preferred]) Learning Environments: CUBE CMLES

	Social Negotiation		Inquiry Learning		Reflective Thinking		Authenticity Learning		Complexity Environment	
	Actual	Preferred	Actual	Preferred	Actual	Preferred	Actual	Preferred	Actual	Preferred
Question										
1	.55	.85								
2	.59	.87								
3	.65	.83								
4	.74	.82								
5	.61	.78								
6			.62	.80						
7			.77	.86						
8			.83	.83						
9			.79	.84						
10			.65	.64						
11					.58	.82				
12					.74	.73				
13					.69	.79				
14					.68	.81				
15					.70	.80				
16							.87	74		
17							.87	76		
18							.71	72		
19							.82	80		
20									.87	.93
21									.87	.91
22									.73	.59
23									.88	.93
24									.79	.82
%Variance	4.84	4.8	3.68	4.24	3.40	4.16	3.29	3.71	2.40	3.3
Alpha Reliability	.82	.92	.85	.88	.91	.86	.87	.85	.93	.88

5.2.2 CMLES Questionnaire

The Questionnaire is decomposed into the following sections, as shown in Table 5.8.

Table 5.8 CMLES Questionnaire

CMLES Questionnaire:		
Questions 1-8: Demographics		
Description	Current (**Actual**) courses	Ideal (**Preferred**) course
Extent to which students have opportunities to discuss their questions and their solutions to questions.	Social Negotiation (Q9-13)	Social Negotiation (Q32-Q37)
Extent to which students are encouraged to engage in inquiry learning.	Inquiry Learning (Q14-18)	Inquiry Learning (Q38-42)
Extent to which students have opportunities to reflect on their own learning and thinking.	Reflective Thinking (Q19-23)	Reflective Thinking (Q43-Q47)
Extent to which the information in the program is authentic and representative of real life situations.	Authenticity of Learning (Q(24-28)	Authenticity of Learning (Q(48-52)
Extent to which the program is complex and represents data in a variety of ways.	Complexity of the Learning Environment (Q29-32)	Complexity of the Learning Environment (Q53-57)
CUBE Analysis Questions		
These questions relate to students experiences using the CUBE knowledge repository.	Presentation (Q58-61)	Content Integration (Q62-67)

5.2.3 Analysis of CMLES Questionnaire Data

The following sections analyze the results from the Constructivist Multimedia Learning Survey (CMLES), gathered during the course of this research. For additional information refer to the Appendix for results and graphs obtained from SAS 9.1.

Demographic Data: There were 85 respondents to the survey broken down into the following demographics:

Table 5.9.A B and C Demographic Data

malefem	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Female	12	14.12	12	14.12
Male	73	85.88	85	100.00

status	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Faculty	4	4.71	4	4.71
Graduate Student (Full Time)	1	1.18	5	5.88
Undergraduate Student (Full Time)	58	68.24	63	74.12
Undergraduate Student (Part Time)	22	25.88	85	100.00

age	Frequency	Percent	Cumulative Frequency	Cumulative Percent
23-30	44	51.76	44	51.76
31-35	6	7.06	50	58.82
over 35	11	12.94	61	71.76
under 23	24	28.24	85	100.00

age				
age	Frequency	Percent	Cumulative Frequency	Cumulative Percent
23-30	44	51.76	44	51.76
31-35	6	7.06	50	58.82
over 35	11	12.94	61	71.76
under 23	24	28.24	85	100.00

Table 5.10 Question: "Have you ever used a discussion board (Dboard)?

Dboard				
Dboard	Frequency	Percent	Cumulative Frequency	Cumulative Percent
More than ten courses	10	11.76	10	11.76
Never	17	20.00	27	31.76
Once or Twice	24	28.24	51	60.00
Three to ten prior courses	34	40.00	85	100.00

Table 5.11 Question: Experience using a learning management system in previous courses.

platform				
platform	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Moodle	7	8.24	7	8.24
Other	9	10.59	16	18.82
WebCT	66	77.65	82	96.47
Webboard	3	3.53	85	100.00

Table 5.12 Breakdown of Students by Course

course				
course	Frequency	Percent	Cumulative Frequency	Cumulative Percent
CPT310	23	27.06	23	27.06
CPT330	4	4.71	27	31.76
CPT341	9	10.59	36	42.35
CPT401	6	7.06	42	49.41
CPT435	11	12.94	53	62.35
CPT493	3	3.53	56	65.88
ECET365	10	11.76	66	77.65
IS350	19	22.35	85	100.00

CMLES CUBE Questions (58-67):

These questions relate to students' experiences using the CUBE knowledge repository. They are broken down into two categories. The first is the students' perceptions of the system and user interface. The second group addresses content integration; i.e. the efficacy of utilizing this approach as it pertains to knowledge acquisition and cohesion of concepts spanning a discipline (Refer to Appendix for SAS source data).

Table 5.13 CMLES CUBE Questions 58 - 67

Knowledge Repository Learning System (CUBE Questions 58-67) Answer these questions based on your experience utilizing the knowledge repository learning system				
Question	**Excellent/ Very good/ good**	**No opinion**	**Poor/very poor/no positive benefit**	total
Presentation:				
58. How would you describe the presentation of multiple courses/content(notes) in one central location	72 88.88%	7 8.67%	2 2.47%	81
59. How would you judge the benefit of the preview page that shows you a graphical overview of the course content?	75 92.59%	5 6.18%	1 1.23%	81
60. How would you evaluate the screen layout using the rubies cube to represent multiple courses?	70 86.14%	7 8.64%	4 4.93%	81
61. How would you describe the user interface: Is it easy to understand how to use the system?	75 92.59%	3 3.7%	3 3.7%	81
Mean	73 90.12%	5.5 6.79%	2.5 3.08%	81
Content Integration				
62. How would you evaluate the knowledge repository approach of aggregating (combining) all the course notes and links between ideas in one central location (web page)?	76 93.82%	3 3.7%	2 2.47%	81
63. How would you evaluate the concept of locating all course information/notes for all four years of your college study in one location/web page?	78 96.29%	3 3.7%	0	81
64. Do you think this option, aggregating all course notes on one location, will add to the learning process?	78 96.29%	3 3.7%	0	81
65. What do you think of the "knowledge map" that links ideas across multiple courses (finding how concepts evolve from one course to another)?	74 91.35%	6 7.41%	1 1.23%	81
66. Do you think that using the knowledge map will help you to learn better?	73 90.12%	7 8.64%	1 1.23%	81
67. What do you think of the presentation method, (i.e. the rubies cube) of viewing courses?	71 87.65%	7 8.64%	3 3.7%	81
Mean	75.8 93.58%	4.83 5.96%	1.16 1.44%	81

Hypothesis **H1**, "Students using the Integrated Knowledge Repository (IKR) will have a more positive perception of the learning process than those who use conventional single course teaching paradigms," is supported by the above data (Table 5.13) that indicates students believe, by over 90%, that the CUBE system will enhance their comprehension of subject matter over conventional single course presentation systems.

Table 5.14 Social Negotiation: Questions 9-13

Please answer this section based on your experiences in your current courses				
Questions: **Social Negotiation**	Almost always/ often/ sometimes	Don't Know	Almost never/ Seldom	Total
9. Students get the chance to communicate with each other.	77 90.58%	2 2.35%	6 7.05%	85
10. Students communicate with each other about how to conduct investigations.	67 78.82%	5 5.88%	13 15.29%	85
11. Students ask other students to explain their ideas	69 81.17%	1 1.18%	15 17.64%	85
12. Students ask me to explain my ideas.	67 78.82%	4 4.71%	14 16.47%	85
13. Other students respond carefully to my ideas.	66 77.64%	5 5.88%	14 16.47%	85
Mean	**69.2** **81.41%**	**3.4** **4%**	**12.4** **14.58%**	**85**

Analysis of Social Negotiation data:

Approximately seventy percent of students are engaged in some forms of social negotiation during their classes, either to share ideas or to collectively engage in making sense of the course materials and concepts presented. This data supports the concepts of constructivism where students are actively engaged in sense making of the ideas and concepts. In addition, since conceptual development appears to be a social construct, the CUBE system, which provides tools for students to share ideas, add new links and concepts and vote on preferred investigative pathways for learning, the social negotiation data appears to be consistent with student's positive attitudes of the CUBE system as indicated by the data in questions 58-67.

Analysis of Inquiry Learning Data:

The Mean of the category, "almost always/ often/ sometimes" was 72.8% (Table 5.15), indicating that students, in their current classes are actively engaged in inquiring learning: asking question, researching sources and analyzing problems from multiple perspectives. Tools that can augment and accelerate this exploration would appear to enhance learning outcomes

Table 5.15 Inquiry Learning Questions 14-18

Answer these questions based on your experiences in your current courses				
Questions: **Inquiry Learning**	Almost always/often/ sometimes	Don't Know	Almost never/ Seldom	Total
14. Students find out answers to questions by investigation.	79 92.94%	1 1.18%	5 5.88%	85
15. Students carry out investigations to test their own ideas.	72 84.7%	2 2.35%	11 12.94%	85
16. Students conduct follow-up investigations to answer emerging questions.	69 81.17%	2 2.35%	14 16.47%	85
17. Students design their own ways of investigating problems.	69 81.17%	3 3.52%	13 15.29%	85
18. Students approach a problem from more than one perspective.	75 88.23%	1 1.18%	9 10.58%	85
Mean	72.8 85.64%	1.8 2.11%	10.4 12.23%	85

Analysis of Reflective Thinking

Students indicated by 74.2% that they reflect on their ideas and learning experiences (Table 5.16). That trait is essential to integrate concepts across an entire discipline, since true learning takes place when the connections are made and the true complexities that bind ideas together create a greater whole/understanding.

Table 5.16 Reflective Thinking Questions 19-23

Please answer this section based on your experiences in your current courses				
Questions: **Reflective Thinking**	Almost always/ often/ sometimes	Don't Know	Almost never/ Seldom	Total
19. Students think carefully about how they learn.	70 83.33%	3 3.57%	11 13.09%	84
20. Students think critically about their own ideas.	76 90.47%	2 2.35%	6 7.14%	84
21. Students learn to be skeptical.	77 91.67%	2 2.35%	5 5.95%	84
22. Students learn to become better learners.	74 88.09%	2 2.38%	8 9.52%	84
23. Students think critically about their own understandings.	74 88.09%	2 2.38%	8 9.52%	84
Mean	**74.2 88.33%**	**2.2 2.58%**	**7.6 9.04%**	**84**

Analysis of Authenticity of learning:

One of the components seemed especially relevant. 77% of the students felt that question 27, "Students need to use a wide range of information to support their problem solving," was important to their integrating all the information presented (Table 5.17). These results mesh with the quantitative results which indicate that, given a wide range of interrelated information that provides meaning and understanding of the discipline as a whole, the better their comprehension of the current course materials.

Table 5.17 Authenticity of Learning Questions 24A-27

Please answer this section based on your experiences in your current courses				
Questions: **Authenticity of Learning**	Almost always/ often/ sometimes	Don't Know	Almost never/ Seldom	Total
24. Students find that the concepts are presented in meaningful contexts.	79 94.04%	1 1.19%	4 4.76%	84
25. Students find that it presents information relevant to them.	75 89.28%	2 2.35%	7 8.33%	84
26. Students find that they are presented with realistic tasks.	77 91.66%	1 1.19%	6 7.14%	84
27. Students need to use a wide range of information to support their problem solving.	77 91.66%	3 3.57%	4 4.76%	84
Mean	77 91.66%	1.75 2.08%	5.25 6.25%	84

Analysis of the Knowledge Repository Learning Environment: Complexity of Learning: The response mean (89.76% ~90%) believed that it was easy to use and learn but more important was the high positive response to question 30, "Students find that it makes them think." The first step in knowledge acquisition is to engage the students and have them think, not just regurgitate the information back, but encourage them to start considering all the possibilities and hopefully surpass the knowledge of the teacher. Providing an evolutionary system that adds to the thinking process, creates a tri-partite learning environment, augmented by the almost infinite capabilities of the global knowledge community.

Table 5.18 Complexity of the Learning Environment: Questions 28-32

Please answer this section based on your experiences in your current courses				
Questions: Complexity of the Learning Environment	Almost always/ often/ sometimes	Don't Know	Almost never/ Seldom	Total
28. Students find it to be user friendly.	76 90.47%	4 4.76%	4 4.76%	84
29. Students find it easy to navigate.	77 91.66%	4 4.76%	3 3.57%	84
30. Students find that it makes them think.	73 86.9%	5 5.95%	6 7.14%	84
31. Students find it easy to use.	75 89.28%	4 4.76%	5 5.95%	84
32. Students take only a short time to learn how to use the system.	76 90.47%	4 4.76%	4 4.76%	
Mean	**75.4** **89.76%**	**4.2** **5.0%**	**4.4** **5.23%**	**84**

Table 5.19 Social Negotiation: Questions 33-37: My ideal Learning Environment

Please answer this section based on your expectations of an Ideal Learning Environment				
Questions: Social Negotiation	Almost always/often/ sometimes	Don't Know	Almost never/ Seldom	Total
33. Students would get the chance to communicate with each other.	78 92.85%	1 1.19%	5 5.95%	84
34. Students would communicate with each other about how to conduct investigations.	79 94.04%	1 1.19%	4 4.76%	84
35. Students would ask other students to explain their ideas.	78 92.85%	1 1.19%	5 5.95%	84
36. Students would ask me to explain my ideas.	77 91.66%	1 1.19 %	6 7.14%	84
37. Other students would respond carefully to my ideas.	78 92.85%	1 1.19%	5 5.95%	84
Mean	**78 92.85%**	**1 1.19%**	**5 5.95%**	**84**

Table 5.20 Inquiry Learning: Questions 38-42: My ideal Learning Environment

Please answer this section based on your expectations of an Ideal Learning Environment.				
Questions. Inquiry Learning	Almost always/often/ sometimes	Don't Know	Almost never/ Seldom	Total
38. Students would find out answers to questions by investigation.	79 94.04%	0	5 5.95%	84
39. Students would carry out investigations to test their own ideas.	80 95.23%	0	4 4.76%	84
40. Students would conduct follow-up investigations to answer emerging questions.	80 95.23%	0	4 4.76%	84
41. Students would design their own ways of investigating problems.	79 94.04%	0	5 5.95%	84
42. Students would approach a problem from more than one perspective.	80 95.23%	1 1.19%	3 3.57%	84
Mean	**79.6** **94.76%**	**0.2** **0.23%**	**4.2** **5.0%**	**84**

Table 5.21 Reflective Thinking: Questions 43-47: My ideal Learning Environment

Please answer this section based on your expectations of an Ideal Learning Environment.				
Questions. Reflective Thinking	Almost always/often/ sometimes	Don't Know	Almost never/ Seldom	Total
43. Students would think carefully about how they learn.	78 92.85%	0	6 7.14%	84
44. Students would think critically about their own ideas.	79 94.04%	0	5 5.95%	84
45. Students would learn to be skeptical.	75 89.28%	1 1.19%	8 9.52%	84
46. Students would learn to become better learners.	80 92.23%	0	4 4.76%	84
47. Students would think critically about their own understandings	78 92.85%	1 1.19%	5 5.95%	
Mean	78 92.85%	0.4 0.47%	5.6 6.7 %	84

Table 5.22 Authenticity of learning: Questions 48-52: My ideal Learning Environment

Please answer this section based on your expectations of an Ideal Learning Environment.				
Questions. Authenticity of Learning	Almost always/often/ sometimes	Don't Know	Almost never/ Seldom	Total
48. Students would find that it reflects the complexity of a real life environment.	78 92.85%	1 1.19%	5 5.95%	84
49. Students would find that the concepts are presented in meaningful contexts.	80 95.23%	2 2.38%	2 2.38%	84
50. Students would find that it presents information relevant to them.	80 95.23%	0	4 4.76%	84
51. Students would find that they are presented with realistic tasks.	82 97.61%	0	2 2.38%	84
52. Students would need to use a wide range of information to support their problem solving.	79 94.04%	0	5 5.95%	
Mean	**79.8 95%**	**0.6 0.71%**	**3.6 4.28%**	**84**

Table 5.23 Complexity of the Learning Environment: Questions 53-57: My ideal Learning Environment

Please answer this section based on your expectations of an Ideal Learning Environment				
Question Complexity of the Learning Environment	Almost always/often/ sometimes	Don't Know	Almost never/ Seldom	Total
53. Students would find it to be user friendly.	81 96.42%	1 1.19%	2 2.38%	84
54. Students would find it easy to navigate.	79 94.04%	1 1.19%	4 4.76%	84
55. Students would find that it makes them think.	76 90.47%	1 1.19%	7 8.33%	84
56. Students would find it easy to use.	80 95.23%	1 1.19%	3 3.57%	84
57. Students would take only a short time to learn how to use the system.	80 95.23%	1 1.19%	3 3.57%	84
Mean	79.2 94.28%	1 1.19%	3.8 4.52%	84

5.2.4 Analysis of CMLES Questions Contrasting Current (Actual) vs. Ideal (Preferred) Courses

The CMLES survey summary table indicates that students prefer an environment where they are active participants in the learning process. They believe that, through social negotiation with fellow students, where they collectively conduct experiments and negotiate meaning derived from those investigations, this interaction would facilitate learning. The additional flexibility derived from inquiry learning where they design their own methods of investigation, seems to indicate the desire to be active participants in designing the learning environment, expressed by collectivist learning theorists.

Table 5.24 Summary of CMLES results

Summary of CMLES results					
Category	**Current/Ideal**	**Almost always/often/ sometimes**	**Don't Know**	**Almost never/ Seldom**	**Ideal vs. Current** (Almost always /Often/ Sometimes)
Social Negotiation	Current courses	81.41%	4%	14.58%	
	Ideal Learning Environment	92.85%	1.19%	5.95%	+8.8%
Inquiry Learning	Current courses	85.64%	2.11%	12.23%	
	Ideal Learning Environment	94.76%	0.23%	5.0%	+6.8
Reflective Thinking	Current courses	88.33%	2.58%	9.04%	
	Ideal Learning Environment	92.85%	0.47%	6.7 %	+3.8%
Authenticity of learning	Current courses	91.66%	2.08%	6.25%	
	Ideal Learning Environment	95%	0.71%	4.28%	+2.8%
Complexity of the Learning Environment	Current courses	89.76%	5.0%	5.23%	
	Ideal Learning Environment	94.28%	1.19%	4.52%	+3.8%

5.2.5 CMLES Questionnaire Results per Question

Table 5.25 CMLES Questionnaire data broken down by question and category

	Mean of each question Don't Know=0, Almost never=1, Seldom=2, Sometime=3, Often=4, Almost Always=5					**Mean of Category**
Current Courses						
Social Negotiation	Q9 3.9176471	Q10 3.2	Q11 3.376471	Q12 3.247059	Q13 3.164706	3.381176
Inquiry Learning	Q14 3.8	Q15 3.517647	Q16 3.329412	Q17 3.352941	Q18 3.776471	3.555294
Reflective Thinking	Q19 3.482353	Q20 3.694118	Q21 3.6	Q22 3.8	Q23 3.670588	3.649412
Authenticity of Learning	Q24A 3.675676	Q24 3.823529	Q25 3.764706	Q26 3.917647	Q27 3.729412	3.782194
Complexity of learning Environment	Q28 3.882353	Q29 3.882353	Q30 3.682353	Q31 3.776471	Q32 3.870588	3.818824
Ideal Environment						
Social Negotiation	Q33 4.070588	Q34 3.952941	Q35 3.823529	Q36 3.776471	Q37 3.870588	3.898824
Inquiry Learning	Q38 3.941176	Q39 4	Q40 3.905882	Q41 3.894118	Q42 4.129412	3.974118
Reflective Thinking	Q43 4.035294	Q44 4.141176	Q45 3.729412	Q46 4.270588	Q47 4.129412	4.061176
Authenticity of Learning	Q48 4.082353	Q49 4.164706	Q50 4.235294	Q51 4.270588	Q52 4.047059	4.16
Complexity of learning Environment	Q53 4.423529	Q54 4.364706	Q55 4.070588	Q56 4.4	Q57 4.329412	4.317647

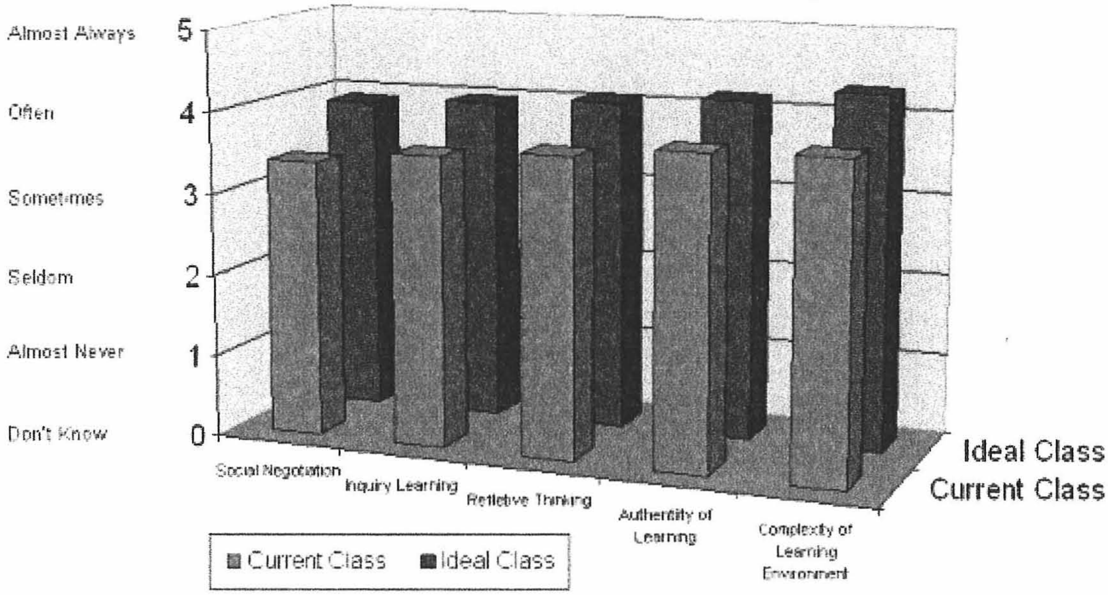


Figure 5.3 CMLES student perceptions of ideal versus current class.

The results from student's evaluation of current course learning environments versus their ideal, preferred, learning environments indicates a desire to enhance their participation and collaboration in all five areas; social negotiation, inquiry learning, reflective thinking, authenticity of learning and the complexity of the learning environment. This is consistent with findings by Maor (1999) (Maor & Fraser, 2000) who originally designed and validated the CMLES instrument (see section 4.3.3). Maor was studying "to what degree students and teachers perceive that their classroom environment involves students in negotiations, inquiry learning and reflective thinking."

Questions 58-67, "analyzing the CUBE learning environment," that refers to the efficacy of integrating concepts spanning an entire discipline, indicates their belief that an integrated knowledge environment linking all their courses into a unified knowledge structure would enhance their comprehension of content areas. This validates hypothesis H1 that "Students using an Integrated Knowledge Repository will have a more positive perception of the learning process than those who use conventional single course teaching paradigms."

5.3 Semantic Web Model Analysis

5.3.1 Background

The Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries. It is a collaborative effort led by W3C with participation from a large number of researchers and industrial partners. It is based on the Resource Description Framework (RDF). (www.W3C.org)

The semantic theory provides an account of meaning in which the logical connection of terms establishes interoperability between systems and heterogeneous data sets. Each piece of data, and any link that connects pieces of data, are identified by a unique name called a Universal Resource Identifier (URI). In the RDF scheme, two pieces of information are connected and grouped together in a triplet to infer relationships between concepts.

The ability to generate complex associations between objects provides the potential to link and grow concepts beyond simple document retrieval. Evolving "concept spaces visually indicate the relationships and important subsets of concepts, particularly subsets that constitute ontological commitments for representing given phenomena. These provide students with large-scale and even global views of the structure of concept spaces." (Smith & Lee, 2004). These complex interrelationships can evolve through input from students and faculty for a potentially richer learner environment.

5.3.2 Semantic Data Collected

The CUBE knowledge repository is structured around a semantic web framework. Students suggest semantic terms that are representative of concepts discussed in both individual courses and terms that span the discipline (refer to Table 5.26).

Concepts Weights: Data collected/ Per Course

Links: (10-20 students/course) x (15 weeks/semester) x (3-7 links/topic) ~ <u>1,100</u>

Voting/weights: Students vote on their top choices

(5 choices/topic) x (15weeks) x (10-20 students) ~<u>1000</u>

Total: Approximately 2100 data points collected per course

Table 5.26 Semantic Terms Suggested by Students

Semantic Web: sample data (refer to appendix)			
Course /Lecture	Topic	Links	Semantic Terms
CPT 310 Lecture 7	Programmable Logic arrays & devices/Decodes/Multiplexers	http://www.cs.northwestern.edu/~agupta/_projects/network_switch/Lectures/CombinatorialCircuitDesign/index.html; http://en.wikipedia.org/wiki/Moore's_law; http://computer.howstuffworks.com/cache.htm; http://reviews.zdnet.co.uk/hardware/components/0,1000001694,39233885,00.htm; http://en.wikipedia.org/wiki/Multi-core	Trace cache, Instruction Cache Moore law Hyper, threading Multiprocessing Symmetric multiprocessing Instruction fetching Vector VIQ Static prediction Dynamic prediction Speculative execution(s) Branch Target Buffer
CPT 435 Ch 18	IP addressing Scheme	www.ralphb.net/IPSubnet/ www.searchwindevelopment.techtarget.com/sDefinition/0,,sid8_gci212381,00.htm www.lawrencegoetz.com/programs/ipinfo/ http://en.wikipedia.org/wiki/Internet_Protocol	Addresses, Virtual, Internet IP Addressing Scheme IP Address Hierarchy Original Classes IP Addresses Computing Class Address Dotted Decimal Notation Classes Dotted Decimal Notation Division Address Space Authority Addresses Glassful Addressing Example Subnet Classless Addressing Address Masks CIDR Notation CIDR Address Block Example Special IP Addresses NW Address Directed Broadcast Address Limited Broadcast Address Loopback Address Berkeley Broadcast Address Form Routers IP Addressing Principle Multi-Homed Hosts
CPT 493 Chapter 2	Biomedical Data: Acquisition and storage	http://en.wikipedia.org/wiki/Medical_imaging http://www1.wfubmc.edu/CBI/Imaging+Informatics/ http://www.isi.uu.nl/CAD/ http://en.wikipedia.org/wiki/Biomedical_informatics http://www.4nsi.com/products/specific-test-products/radiography	Magnetic Response Imaging (MRI) Medical Imaging Imaging Informatics Ultrasound Computer Aided Diagnosis (CAD) Image Storage X-Ray CT scan (Computer Tomography)

5.3.3 Ranking / Voting (semantic terms, links and Relationships)

Once the links have been colleted, students evaluate links and vote/ rank their top five choices. Following Bloom's Revised Taxonomy (Anderson, et al. 2001) students rank the quality of the links/content in terms of three categories: Factual Knowledge, Conceptual Knowledge and Procedural knowledge.

- Factual Knowledge: The basic elements students must know to be acquainted with a discipline or solve problems in it.
    - Knowledge of terminology technical vocabulary
- Conceptual Knowledge: The interrelationships among the basic elements within a larger structure that enable them to function together.
    - Knowledge of classifications and categories:
    - Knowledge of principles and generalizations
    - Knowledge of theories, models and structures
- Procedural Knowledge: How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.
    - Knowledge of subject-specific skills and algorithms:
    - Knowledge of criteria for determining when to use appropriate procedures

Table 5.27 Links and Rankings for CPT 435-Lecture 7: Composite Score of Factual, Conceptual & Procedural Knowledge Components

Ranking / Voting Links (example)						
Course	**Links**	Ranking 1-5	Factual Knowledge	Conceptual Knowledge	Procedural Knowledge	Mean
CPT 435	• http://en.wikipedia.org/wiki/Cyclic_redundancy_check	1	67	74	73	71.33
Lecture 7	• http://en.wikipedia.org/wiki/Packet_(information_technology	2	63	65	65	64.33
	• http://en.wikipedia.org/wiki/Parity_bit	3	69	53	64	62.0
	• http://computer.howstuffworks.com/question525.htm	4	48	49	41	46.0
	• http://en.wikipedia.org/wiki/Bit_stuffing	5	22	14	21	19.0

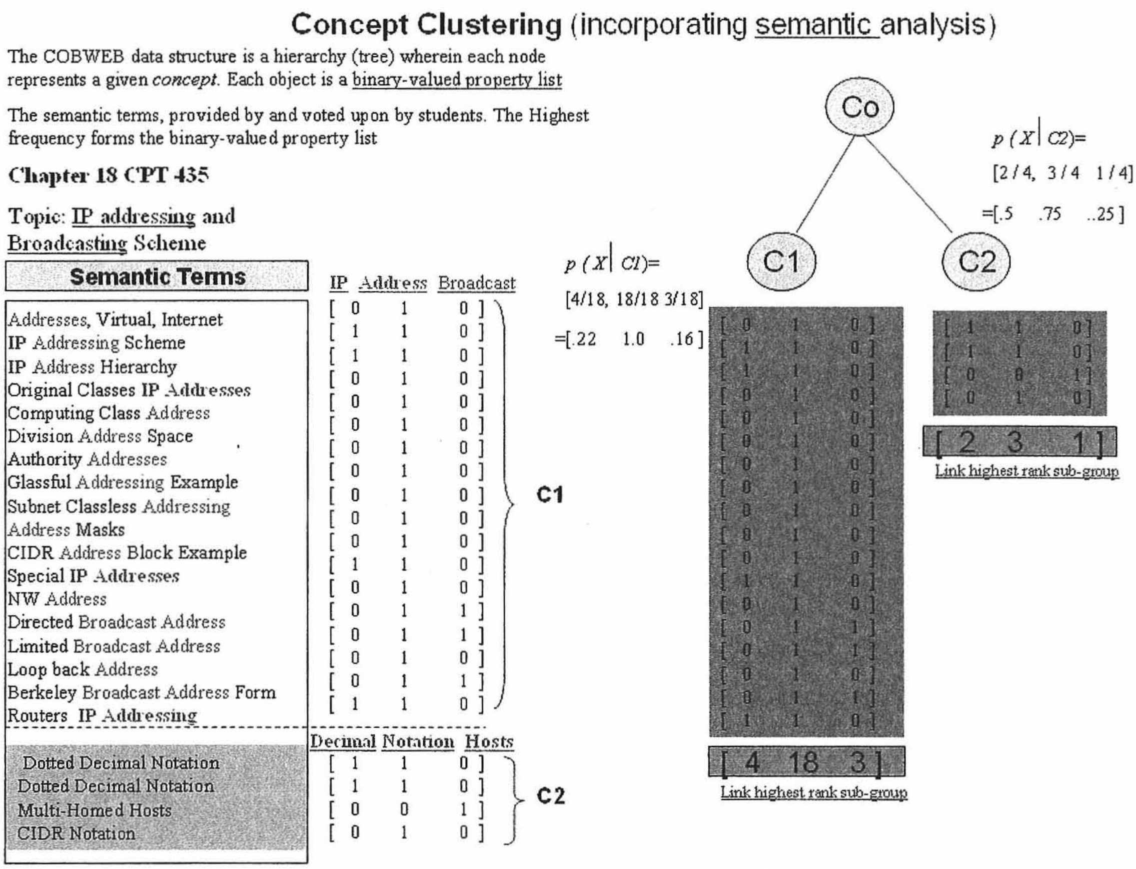


Figure 5.4 Concept clustering (incorporating semantic analysis).

The following is an example of the ranking output from the CUBE learning Environment.

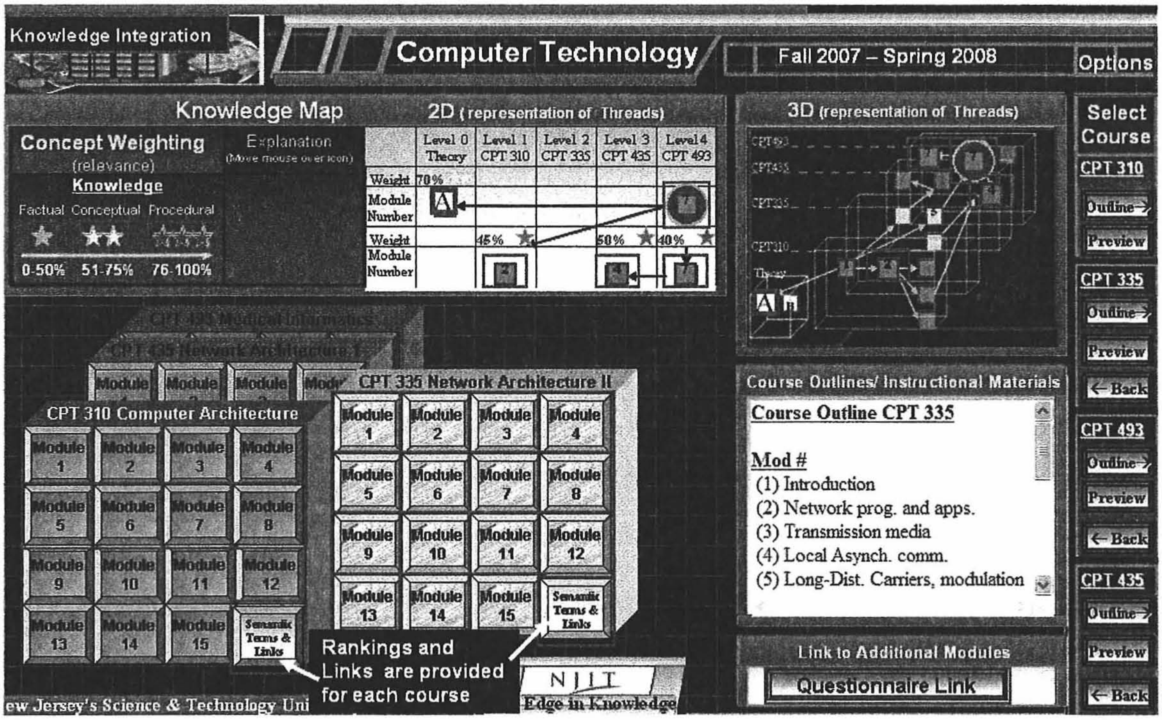


Figure 5.5 CUBE screen: each course has access to the rankings/ top 5 links.

Week 1 ***course syllabus link***

Week 2

top 5 sites		Excellent	Very Good	No Opinion	Bad	very Bad
1	http://computer.howstuffworks.com/computer-memory.htm	X				
2	http://www.patentstorm.us/patents/6332191-claims.html		X			
3	http://arstechnica.com/articles/paedia/cpu/core.ars/7			X		
4	http://www.eng.umd.edu/~nsw/ench250/number.htm.			X		
5	http://en.wikipedia.org/wiki/Gray_codec			X		

Week 3

top 5 sites		Excellent	Very Good	No Opinion	Bad	very Bad
1	http://www.iit.edu/~noahlan/index_over.html	X				
2	http://arantxa.ii.uam.es/~jlara/investigacion/ecomm/electronica/comb.html		X			
3	http://academic.evergreen.edu/projects/biophysics/technotes/program/2s_comp.htm	X				
4	http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elevol.html			X		
5	http://publib.boulder.ibm.com/infocenter/systems/index.jsp? topic=/com.ibm.aix.commadmn/doc/commadmndita/asynch_params_parity.htm			X		

Week 4

top 5 sites		Excellent	Very Good	No Opinion	Bad	very Bad
1	http://courseware.ee.calpoly.edu/~rsandige/KarnaughExplorer.html	X				
2	http://www.cs.unb.ca/courses/cs2813/slides/LCDF3_Chap_03_P1.pdf	X				
3	http://nobelprize.org/educational_games/physics/integrated_circuit/history/index.html		X			
4	http://searchnetworking.techtarget.com/sDefinition/0,,sid7_gci939061,00.html		X			
5	http://www.kpsec.freeuk.com/components/ic.htm			X		

Figure 5.6 Actual output from the rankings and links for CPT 310.

The feedback from the students' impressions of the rankings was very positive. The ability to explore additional material, which helps clarify the concepts covered, appeared to empower them as active participants in the learning process. In addition, for instructors who may have limited time to explore and add new course content, the quality of the course would be richer with greater depth with the additional content provided by the students. Regarding assisting students with homework, students added links that provided graphical tools that allowed students to explore and understand the problem solving process in greater depth than would normally occur.

The eventual goal of a true knowledge repository, for a particular discipline, is for it to organically evolve and grow to the point where students, faulty and researchers add to the content. Faculty devotes a great deal of time duplicating work and tools that are already available at other universities. The challenge to keep materials timely is an enormous task that often is not realized. The additional materials, links that the students provided have substantially enhanced the quality of the course content by incorporating tools found at other open source web sites. Maintaining state of the art course material is essential to insure students are prepared for the rapidly evolving technological environment.

The term "Concept Spaces" (Smith, Lee 2004) was defined as *"the ability to generate complex associations between objects provides the potential to link and grow concepts beyond simple document retrieval. These evolving Concept Spaces visually indicate the relationships and important subsets of concepts, particularly subsets that constitute ontological commitments for representing given phenomena."* These complex interrelationships can potentially evolve through input from students and faculty for a richer learning environment.

CHAPTER 6

CONCLUSION

A number of Constructivist theorists, (Piaget, 1920) (Vygotsky, 1934) (Bruner, 1960) (Jonassen, 1991), have postulated that knowledge formation is a dynamic process where learners actively construct a representation of concepts, integrating information from multiple sources. Realizing this elusive goal of developing a true constructivist learning environment, has eluded researchers for the past century. During the past decade, a number of theories and technologies have surfaced to facilitate these aspirations. The ubiquitous World Wide Web that connects us in almost real time has facilitated information exchange. Theories and data structures such as the Semantic-Web (Berners-Lea, 2001) and the Resource Description framework (World Wide Web Consortium) have provided the framework on which to build a truly interactive knowledge repository.

Most educational paradigms have followed a serial/sequential approach where the connectivity of concepts, procedures, algorithms and accumulated knowledge that tie a discipline together rely on students to make the philosophical leap; the "aha" moment, where the clarity of interconnected nature of ideas eventually becomes apparent. In the optimum scenario all students would eventually achieve this goal. However, from many years of teaching experience, the majority of students absorb facts but not the tapestry that interconnects them. This contribution is intended to provide the means, models and tools which will allow students, from their earliest studies, to develop and explore these conceptual threads that tie a discipline together. This was accomplished by taking constructivist theories to the next level and developing a structure, several models, and a prototype knowledge repository to facilitate knowledge formation spanning an entire discipline. Students in an introductory course were encouraged to explore more complex concepts by traversing the concept maps. They may not initially fully comprehend the complexities of the advanced concepts but are introduced to the underlying rationale of the current information and where it would lead. This also provides a natural link between instructors and courses where students know before entering a more advanced topic why the next sequence is offered. This is quite possibly the underlying explanation for the excellent results of this study. Students were initially shown the path in their introductory courses and, when they eventually encountered more complex terrain in more advanced courses, the rationale and purpose were immediately apparent.

The results of this research indicate the potential that integrated learning environments have for improving both performance and knowledge comprehension. By integrating course materials spanning a discipline, utilizing a web-based tool that allows students to be active participants in constructing meaning. Constructivist Learning has the potential for creating more engaging and effective learning environments. Students utilizing the CUBE knowledge repository showed an average increase of 23.46 points in test scores on a standardized exam over students taking the conventional single course method. The exam consisted of a ten question multiple choice exam that covered materials than evaluated procedural knowledge than spanned the last two years of the curriculum. The improvement represented two and a half questions on that exam. The combination of improved perceptions by the students of this approach and some reasonable quantitative improvement in test scores seem to indicate the potential of this approach.

Cognitive Load Theory (Sweller, 1988) states that, "optimum learning occurs in humans when the load on working memory is kept to a minimum to best facilitate the changes in long term memory." He found that the format of instructional materials has a direct effect on the performance of the learners using those materials. The visual presentation medium of the knowledge repository has shown that, using Cognitive Load Theory, the students believe that the aggregation of all course materials for a discipline in a central location facilitates knowledge building, since they can easily navigate the continuum of simple-to-complex factual and procedural knowledge relationships. In addition, the knowledge maps facilitate this retention by showing all the complex links between concepts.

Current teaching paradigms have not fully utilized the powerful computational capabilities of the current technology. They have essentially automated the presentation of the course materials but not radically changed the organization of the information presented. The goal of this research was to incorporate the concepts laid out by the Constructivist Learning Environment theories to engage students in truly collaborative learning environments where they can explore and construct a unified vision of a content area. The shared data repository appears to facilitate students' knowledge integration by having them navigate through collaborative scenarios that integrate the knowledge of an entire discipline. This research seems to provide promising indications that the nature of on-line instruction can evolve to a higher level of interactive and collaborative learning. In addition, by aggregating the knowledge of an entire discipline into a reusable core database that weights and organizes a discipline's data according to its importance, we can provide students with a better understanding of the cohesion of thought and processes that ties a discipline together.

What wasn't apparent before this study was that there could be a quantifiable increase in understanding of a discipline by students if they had access to more advanced concepts and topics at the earliest level of instruction. The ability to visualize and explore the entire discipline, even without full comprehension of all details of the more complex concepts, facilitated better understanding of their current level of study. By knowing the purpose and direction of their current studies, rather than at the end of their studies in a terminal course, but reinforced all along the way, students didn't need the "aha" moment; They could visualize the roadmap at the outset and could traverse familiar well-defined pathways, reinforcing the cohesion of ideas and ensuring an integrated view of the discipline.

The limitations of this research, which was conducted during the course of two years, covering four courses in Computer Technology, were that the research focused on one discipline and included only a subset of all the course content of that discipline. An expanded study would compare and contrast outcomes in several disciplines such as Liberal Arts, Basic Sciences, and Engineering. In addition, every significant course in that field of study, including basic core courses could be integrated into the knowledge base for a more complete understanding of benefits and limitations that underlie this research.

This research has shown promising indications that integrating concepts across a discipline will yield individuals with a better understanding of the cohesion of concepts that interconnect a field of study. There are several areas of future research that could be explored to create a knowledge repository that truly spans a discipline. By integrating this knowledge repository across multiple disciplines in a university, students could develop a better understanding of the linkages between all the complementary fields of study. In addition, by expanding the scope of these knowledge repositories to several universities and then to the discipline as a whole, the scope of the integrated knowledge repository would truly represent the depth and complexity of the entire field. Eventually, a global interconnected knowledge repository could encompass all fields. There is currently a compartmentalized view of information. Lessons learned from one field often slowly propagate to others. Knowledge in one field doesn't always quickly migrate to others. The hope is that by creating integrated knowledge repositories, not only will educational paradigms evolve but boundaries between disciplines will diminish.

APPENDIX A

CONSTRUCTIVIST MULTIMEDIA LEARNING SURVEY (CMLES)

The Constructivist Multimedia Learning Environment Survey (CMLES) is designed to assess students and teachers perceptions on their constructivist learning environment while they interacted with multimedia programs. In particular, the CMLES examined to what degree students and teachers perceive that their classroom environment involves students in negotiations, inquiry learning and reflective thinking.

Knowledge Repository Research Questionnaire Ver 2

Consent Form Knowledge Repository Pilot Study

NEW JERSEY INSTITUTE OF TECHNOLOGY
323 MARTIN LUTHER KING BLVD.
NEWARK, NJ 07102

CONSENT TO PARTICIPATE IN A RESEARCH STUDY
TITLE OF STUDY: Collaborative Learning Utilizing a Shared Data Repository Spanning Multiple Courses: A Pilot Study
RESEARCH STUDY:

* I (Enter your full name):

have been asked to participate in a research study under the direction of Drs. George Widmeyer and David Lubliner. Other professional persons who work with them as study staff may assist to act for them.

PURPOSE:
The purpose of the study is to test a new teaching and learning paradigm. A web based interactive learning environment has been constructed to present and integrate the instructional materials of four interrelated Computer Technology courses. The courses are: CPT 310 Computer Architecture, CPT 335 Intro to Computer Networks, CPT 435 Advanced Computer Networks and CPT 493 Medical Informatics. The learning environment displays conceptual threads that connect concepts that span the knowledge of an entire discipline. Students currently taking these courses will be given the opportunity to compare and contrast learning experiences using both approaches. In addition students who have already completed these courses will use the new tool to evaluate it as a potential alternative for future instruction.

DURATION:
My participation in this study will last for (one hour completing an assignment utilizing the Knowledge Repository; about 30 minutes for answering a questionnaire)

PROCEDURES:
I have been told that, during the course of this study, the following will occur:

1. You will be given a brief introduction to the system and asked to test out the system. 2. You will be asked to complete a questionnaire to provide feedback on your experiences.

PARTICIPANTS:
I will be one of about 150 participants in this study.

EXCLUSIONS:
I will inform the researcher if any of the following apply to me:
You must be 18 years of age or older.

Knowledge Repository Research Questionnaire Ver 2

Consent Form

RISKS/DISCOMFORTS:
I have been told that the study described above may involve the following risks and/or discomforts: We are not aware of any risks associated with completing the questionnaire.
There also may be risks and discomforts that are not yet known.
I fully recognize that there are risks that I may be exposed to by volunteering in this study which are inherent in participating in any study; I understand that I am not covered by NJIT's insurance policy for any injury or loss I might sustain in the course of participating in the study.

CONFIDENTIALITY:
I understand confidential is not the same as anonymous. Confidential means that my name will not be disclosed if there exists a documented linkage between my identity and my responses as recorded in the research records. Every effort will be made to maintain the confidentiality of my study records. If the findings from the study are published, I will not be identified by name. My identity will remain confidential unless disclosure is required by law. In particular: Your name is required on the consent form and to give you credit for completing the questionnaire. However, an ID will be assigned, and the questionnaire that is entered into a database will not have your name on it.

PAYMENT FOR PARTICIPATION:
I have been told that I will receive No monetary compensation for my participation in this study.
However, all partticipants will be entered into a raffle for an IPhone. It is anticipated the raffle will be held at the end of the semester.

RIGHT TO REFUSE OR WITHDRAW:
I understand that my participation is voluntary and I may refuse to participate, or may discontinue my participation at any time with no adverse consequence. (Note: If you withdraw from the study, you will have a reasonable amount of time to complete the alternate assignment instead.) I also understand that the investigator has the right to withdraw me from the study at any time.

INDIVIDUAL TO CONTACT:
If I have any questions about my treatment or research procedures, I understand that I should contact the principal investigator at:

George Widmeyer:
Email: Widmeyer@njit.edu
Phone: 973-596-5597

David Lubliner:
Email: Lubliner@njit.edu
Phone: 973-596-2878

(Dr. Widmeyer is a professor in the Information Systems Department, GITC, NJIT. David Lubliner is a University Lecturer in the Computer Technology Department.)

If I have any additional questions about my rights as a research subject, I may contact:

Dawn Hall Apgar, PhD, IRB Chair
New Jersey Institute of Technology
323 Martin Luther King Boulevard
Newark, NJ 07102
(973) 642-7616
dawn.apgar@njit.edu

* **I have read this entire form, or it has been read to me, and I understand it completely. All of my questions regarding this form or this study have been answered to my complete satisfaction. I am indicating my agreement to participate in this research study by selecting the "ACCEPT" option below.**

( ) ACCEPT ( ) DO NOT ACCEPT

Knowledge Repository Research Questionnaire Ver 2

Demographic Information

Knowledge Repository Survey

Directions

There are four sets of questions. The first set asks for demographic information. The second set asks for your opinion about your experiences with courses that you have taken. The third set is to be answered based on your expectations for the most desirable learning environment. Finally, the fourth set of questions relates to the new system (Knowledge Repository) that you have just tested. There are no right or wrong answers. Your answers will not affect your class grade. Your opinion is what is wanted. Thank you very much for your kind assistance.

*** Preliminary Information**

1. Your name:

*** 2. Your status:**

- ○ Faculty
- ○ Undergraduate Student (Full Time)
- ○ Undergraduate Student (Part Time)
- ○ Graduate Student (Full Time)
- ○ Graduate Student (Part Time)

*** 3. Course number and name:**

*** 4. I am a:**

- ○ Female
- ○ Male

*** 5. My age is:**

- ○ under 23
- ○ 31-35
- ○ 23-30
- ○ over 35

*** 6. English is my native or first language.**

- ○ Yes
- ○ No

*** 7. I have used a discussion board in a course before.**

- ○ Never
- ○ Three to ten prior courses
- ○ Once or Twice
- ○ More than ten courses

*** 8. Experience using a learning management system in previous courses: Check all that apply.**

- ○ WebCT
- ○ Webboard
- ○ Moodle
- ○ Other

Knowledge Repository Research Questionnaire Ver 2

Faculty Page

To be answered only by faculty

Evalution of the Knowledge Repository aggregation approach to teaching courses

	absolutely	very probably	probably	no opinion	unlikely	very unlikely	Never
F1. Do you believe that you would use the knowledge repository for your courses that allows you to present information/course notes for multiple courses in the same location/web site?	☐	☐	☐	☐	☐	☐	☐
F2. Do you see any educational benefit to presenting course materials for multiple interrelated courses in a single location?	☐	☐	☐	☐	☐	☐	☐
F3. Do you believe the knowledge map that shows the linkage between concepts that span multiple courses would be useful to students in better understanding relationships between concepts?	☐	☐	☐	☐	☐	☐	☐
F4. If the tools were available and easy to use, would you prefer placing your course materials on the web yourself?	☐	☐	☐	☐	☐	☐	☐
F5. Would you be willing to be part of a trial to test out a system like this in your courses?	☐	☐	☐	☐	☐	☐	☐
F6. If you are be willing to test this new system, would you prefer a user interface that allowed you to enter the information yourself?	☐	☐	☐	☐	☐	☐	☐
F7. If you are willing to test this new system, would you prefer to have someone else enter the data in to the system?	☐	☐	☐	☐	☐	☐	☐
F8. In summary, do you believe this avenue of research, will lead to a paradigm shift in teaching?	☐	☐	☐	☐	☐	☐	☐

Knowledge Repository Research Questionnaire Ver 2

Current Courses

Please answer this section based on your experiences in your current courses

* Social Negotiation

	Almost Never	Seldom	Sometimes	Often	Almost Always	Don't Know
9. Students get the chance to communicate with each other.	○	○	○	○	○	○
10. Students communicate with each other about how to conduct investigations.	○	○	○	○	○	○
11. Students ask other students to explain their ideas.	○	○	○	○	○	○
12. Students ask me to explain my ideas.	○	○	○	○	○	○
13. Other students respond carefully to my ideas.	○	○	○	○	○	○

* Inquiry Learning

In this class...

	Almost Never	Seldom	Sometimes	Often	Almost Always	Don't Know
14. Students find out answers to questions by investigation.	○	○	○	○	○	○
15. Students carry out investigations to test their own ideas.	○	○	○	○	○	○
16. Students conduct follow-up investigations to answer emerging questions.	○	○	○	○	○	○
17. Students design their own ways of investigating problems.	○	○	○	○	○	○
18. Students approach a problem from more than one perspective.	○	○	○	○	○	○

Knowledge Repository Research Questionnaire Ver 2

Current Courses

Please answer this section based on your experiences in your current courses

* *Reflective Thinking*

	Almost Never	Seldom	Sometimes	Often	Almost Always	Don't Know
19. Students think carefully about how they learn.						
20. Students think critically about their own ideas.						
21. Students learn to be skeptical.						
22. Students learn to become better learners.						
23. Students think critically about their own understandings.						

* *Authenticity of Learning*

When working with the content of this class...

	Almost Never	Seldom	Sometimes	Often	Almost Always	Don't Know
24A. Students find that it reflects the complexity of a real life environment.						
24. Students find that the concepts are presented in meaningful contexts.						
25. Students find that it presents information relevant to them.						
26. Students find that they are presented with realistic tasks.						
27. Students need to use a wide range of information to support their problem solving.						

Knowledge Repository Research Questionnaire Ver 2

Knowledge Repository learning environment

Questions about the Knowledge Repository Learning Environment
Click on the option that best describes your impression of the new system that you have just tested.

* *Complexity of the Learning Environment*

	Almost Never	Seldom	Sometimes	Often	Almost Always	Don't Know
28. Students find it to be user friendly.	○	○	○	○	○	○
29. Students find it easy to navigate.	○	○	○	○	○	○
30. Students find that it makes them think.	○	○	○	○	○	○
31. Students find it easy to use.	○	○	○	○	○	○
32. Students take only a short time to learn how to use the system.	○	○	○	○	○	○

Knowledge Repository Research Questionnaire Ver 2

Ideal Learning Environment

Answer these questions based on your ideal learning environment

* *Reflective Thinking*

In my ideal class...

	Almost Never	Seldom	Sometimes	Often	Almost Always	Don't Know
43. Students would think carefully about how they learn.						
44. Students would think critically about their own ideas.						
45. Students would learn to be skeptical.						
46. Students would learn to become better learners.						
47. Students would think critically about their own understandings						

* *Authenticity of Learning*

When working with the content of my ideal class...

	Almost Never	Seldom	Sometimes	Often	Almost Always	Don't Know
48. Students would find that it reflects the complexity of a real life environment.						
49. Students would find that the concepts are presented in meaningful contexts.						
50. Students would find that it presents information relevant to them.						
51. Students would find that they are presented with realistic tasks.						
52. Students would need to use a wide range of information to support their problem solving.						

Knowledge Repository Research Questionnaire Ver 2

Ideal Online Learning Environment

Answer these questions based on your ideal online learning environment

* *Complexity of the Learning Environment*

Working with a system for my ideal online class...

	Almost Never	Seldom	Sometimes	Often	Almost Always	Don't Know
53. Students would find it to be user friendly.	○	○	○	○	○	○
54. Students would find it easy to navigate.	○	○	○	○	○	○
55. Students would find that it makes them think.	○	○	○	○	○	○
56. Students would find it easy to use.	○	○	○	○	○	○
57. Students would take only a short time to learn how to use the system.	○	○	○	○	○	○

Knowledge Repository Research Questionnaire Ver 2

Knowledge Repository Learning System

Answer these questions based on your experience with the Knowledge Repository Learning System that you have just tested

* Presentation:

	Excellent	very good	good	no opinion	poor	very poor	no positive benefit
58. How would you describe the presentation of multiple courses/content(notes) in one central location	○	○	○	○	○	○	○
59. How would you judge the benefit of the preview page, that shows you a graphical overview of the course content.	○	○	○	○	○	○	○
60. How would you evaluate the screen layout using the rubix cube to represent multiple courses.	○	○	○	○	○	○	○
61. How would you describe the user interface: Is it easy to understand how to use the system?	○	○	○	○	○	○	○

* Content Integration

	Excellent	very good	good	no opinion	poor	very poor	no positive benefit
62. How would you evaluate the knowledge repository approach of aggregating (combining) all the course notes and links between ideas in one central location (web page)?	○	○	○	○	○	○	○
63. How would you evaluate the concept of locating all course information/notes for all four years of your college study in one location/web page?	○	○	○	○	○	○	○
64. Do you think this option, aggregating all course notes on one location, will add to the learning process?	○	○	○	○	○	○	○
65. What do you think of the "knowledge map" that links ideas accross multiple courses (finding how concepts evolve from one course to another)?	○	○	○	○	○	○	○
66. Do you think tht using the knowledge map will help you to learn better?	○	○	○	○	○	○	○
67. What do you think of the presentation method, (i.e. the rubix cube) of	○	○	○	○	○	○	○

Knowledge Repository Research Questionnaire Ver 2

Thank You

Thank your for your participation.
George R. Widmeyer and David Lubliner
New Jersey Institute of Technology

APPENDIX B

INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL

This is the application for approval of a research project that was submitted to c the Institutional Review Board of New Jersey Institute of Technology. Approval was granted on October 26, 2007.

NJIT NEW JERSEY INSTITUTE OF TECHNOLOGY

Institutional Review Board: HHS FWA 00003246
Notice of Approval
IRB Protocol Number: E105-07

Principal Investigators: David Lubliner and George Widmeyer
Information Systems

Title: Collaborative Learning: Utilizing a Shared Data Repository Spanning Multiple Courses to Enhance Learning Outcomes in Asynchronous Learning Environments

Performance Site(s): NJIT Sponsor Protocol Number (if applicable):

Type of Review: FULL [ ] EXPEDITED [X]

Type of Approval: NEW [X] RENEWAL [ ] REVISION [ ]

Approval Date: October 26, 2007 Expiration Date: October 25, 2008

1. **ADVERSE EVENTS:** Any adverse event(s) or unexpected event(s) that occur in conjunction with this study must be reported to the IRB Office immediately (973) 642-7616.

2. **RENEWAL:** Approval is valid until the expiration date on the protocol. You are required to apply to the IRB for a renewal prior to your expiration date for as long as the study is active. It is your responsibility to ensure that you submit the renewal in a timely manner.

3. **CONSENT:** All subjects must receive a copy of the consent form as submitted. Copies of the signed consent forms must be kept on file with the principal investigator.

4. **SUBJECTS:** Number of subjects approved: 200.

5. The investigator(s) did not participate in the review, discussion, or vote of this protocol.

6. **APPROVAL IS GRANTED ON THE CONDITION THAT ANY DEVIATION FROM THE PROTOCOL WILL BE SUBMITTED, IN WRITING, TO THE IRB FOR SEPARATE REVIEW AND APPROVAL.**

Dawn Hall Apgar

Dawn Hall Apgar, PhD, LSW, ACSW, Chair IRB October 26, 2007

Institutional Review Board: HHS FWA 00003246
Notice of Approval

NJIT NEW JERSEY INSTITUTE OF TECHNOLOGY

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Dawn Hall Apgar

Dawn Hall Apgar, PhD, LSW, ACSW, Chair IRB October 26, 2007

APPENDIX C

IRB APPROVAL AND PARTICIPANT CONSENT

This is a copy of the consent that students signed prior to their participation in this research project.

NEW JERSEY INSTITUTE OF TECHNOLOGY
323 MARTIN LUTHER KING BLVD.
NEWARK, NJ 07102

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

TITLE OF STUDY: Second Life as a Learning Environment: A Pilot Study

RESEARCH STUDY:
I, ____, have been asked to participate in a research study under the direction of Drs. George Widmeyer and Starr Roxanne Hiltz. Other professional persons who work with them as study staff may assist to act for them.

PURPOSE:
Massively Multi-Member Online Worlds (MMOWs) are graphically-rich, three-dimensional (3D), electronic environments where members assume an embodied persona (i.e., avatars) and engage in socializing, competitive quests, learning, and/or economic transactions with globally-distributed others. Frequently categorized as technologies of play, MMOWs range from massively multi-player online games (MMOGs) such as World of Warcraft to virtual reality environments such as Second Life.

The aim of the larger project is to test the claim that use of a specific online world (e.g., Moodle plus Second Life) can make a statistically significant difference in engaging and meaningful learning for students. We intend to make some experimental enhancements of Second Life and test their effectiveness for students and faculty.

The aim of this pilot project is to assess the first draft of the research instrument and to explore what, if any, problems will have to be solved for students to use Second Life at NJIT.

DURATION:
My participation in this study will last for (several hours completing an assignment in Second Life; about 30 minutes for answering a questionnaire)

PROCEDURES:
I have been told that, during the course of this study, the following will occur:

1. Your instructor will give you an assignment that can be completed by interacting with your class mates in Second Life, or by doing a literature search and writing a short paper
2. You will be asked to complete a post-assignment questionnaire to provide feedback on your experiences.

PARTICIPANTS:
I will be one of about 300 participants in this study.

EXCLUSIONS:
You must be 18 years of age or older.

RISKS/DISCOMFORTS:
I have been told that the study described above may involve the following risks and/or discomforts. We are not aware of any risks associated with completing the questionnaire.

There also may be risks and discomforts that are not yet known.

I fully recognize that there are risks that I may be exposed to by volunteering in this study which are inherent in participating in any study; I understand that I am not covered by NJIT's insurance policy for any injury or loss I might sustain in the course of participating in the study.

CONFIDENTIALITY:
I understand confidential is not the same as anonymous. Confidential means that my name will not be disclosed if there exists a documented linkage between my identity and my responses as recorded in the research records. Every effort will be made to maintain the confidentiality of my study records. If the findings from the study are published, I will not be identified by name. My identity will remain confidential unless disclosure is required by law. In particular: Your name is required on the consent form and to give you credit for completing the questionnaire. However, an ID will be assigned, and the questionnaire that is entered into a database will not have your name on it.

PAYMENT FOR PARTICIPATION:
I have been told that I will receive no monetary compensation for my participation in this study.

However, your instructor may have announced the availability of extra credit for participating in this project. If so, the exact number of extra credit points, and an alternative for earning the same number of points, will be described by your course instructor.

RIGHT TO REFUSE OR WITHDRAW:
I understand that my participation is voluntary and I may refuse to participate, or may discontinue my participation at any time with no adverse consequence. (Note: If you withdraw from the study, you will have a reasonable amount of time to complete the alternate assignment instead.) I also understand that the investigator has the right to withdraw me from the study at any time.

INDIVIDUAL TO CONTACT:
If I have any questions about my treatment or research procedures, I understand that I should contact the principal investigator at

George Widmeyer.
Email. Widmeyer@njit.edu
Phone. 973-596-5897

Roxanne Hiltz.
Email. Hiltz@njit.edu
Phone. 973-596-3388

(Both are professors in the Information Systems Department, GITC, NJIT)

If I have any addition questions about my rights as a research subject, I may contact

Dawn Hall Apgar, PhD, IRB Chair
New Jersey Institute of Technology
323 Martin Luther King Boulevard
Newark, NJ 07102
(973) 642-7616
dawn.apgar@njit.edu

SIGNATURE OF PARTICIPANT

I have read this entire form, or it has been read to me, and I understand it completely. All of my questions regarding this form or this study have been answered to my complete satisfaction. I agree to participate in this research study.

Subject Name ______________________________

Signature.______________________________

Date.______________

SIGNATURE OF INVESTIGATOR OR RESPONSIBLE INDIVIDUAL (Only required for consent forms of projects requiring full IRB approval)

To the best of my knowledge, the participant, ______________, has understood the entire content of the above consent form, and comprehends the study. The participants and those of his/her parent/legal guardian have been accurately answered to his/her/their complete satisfaction.

Investigator's Name.______________________________

Signature.______________________________

Date:__________

NJIT

Approved by the NJIT IRB on 6/26/07.
Modifications may not be made to this consent form without NJIT IRB approval.

APPENDIX D

SEMI-STRUCTURED INTERVIEW QUESTIONNAIRE (PILOT TESTING)

These were the questions that were asked as part of the semi-structured interview.

Semi-Structured Interview Questions
Pilot Study

1. How would you describe the presentation of multiple courses/content (notes) in one central location?
2. How would you judge the benefits of the preview page that shows you a graphical overview of the course content?
3. How would you evaluate the screen layout using a cube to represent multiple courses?
4. How would you describe the user interface: Is it easy to understand how to use the system?
5. What do you think of the "knowledge map" that links ideas across multiple courses (finding how concepts evolve from one course to another)?
6. How would you evaluate the knowledge repository approach of aggregating (combining all the courses notes and links between ideas in one central location (web page)?

Semi-Structured Interview Questions
Final Questionnaire

1. How would you describe the presentation of multiple courses/content (notes) in one central location?

   1a.Follow up question

   Do you believe the new system will help you learn the material any better.
2. How would you judge the benefits of the preview page that shows you a graphical overview of the course content?

   2a.Follow up question

   Do you think it helps a student understand or see what is going?
   on in the course better or worst than the standard text only
   course outline.
3. How would you evaluate the screen layout using the cube to represent multiple courses?

   3a. Follow up question

   Can you think of a better way of representing multiple courses?
4. How would you describe the user interface: Is it easy to understand how to use the system?

   4a.Follow up question

   Is there anything specific you did not like about how the screen is set-up?
5. What do you think of the "knowledge map" that links ideas across multiple courses (finding how concepts evolve from one course to another)?

   5a.Follow up question

   What do you think of the 2D version vs. the 3D version? Better or worse: should you have both?

   5b.Follow up question

   Do you prefer the 3D version, and maybe larger hiding 2D version?

<u>5c.Follow up question</u>

What do you think of this knowledge map? Will it help you learn and understand what is going on in the courses? Will it be better or worse?

6. How would you evaluate the knowledge repository approach of aggregating (combining all the courses notes and links between ideas in one central location (web page)?

<u>6a.Follow up question</u>

Do you think the idea of teaching courses differently, where you have all of the information of multiple courses available to you, is a better or worse way of presenting the information?

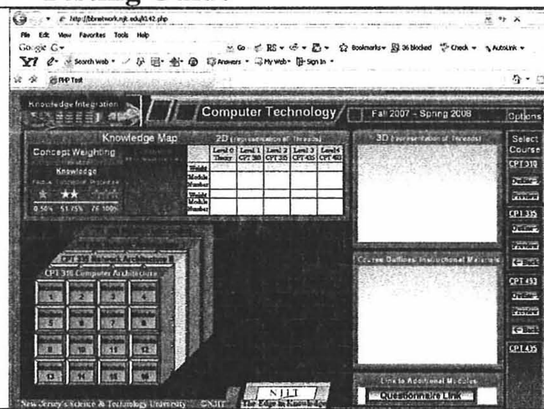
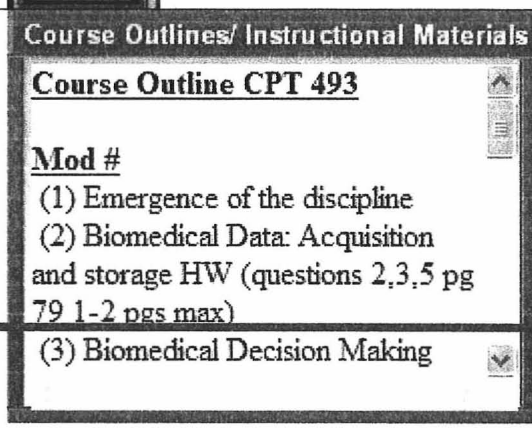
APPENDIX E

SEMI-STRUCTURED INTERVIEW TESTING GUIDE

The following testing guide was provided to all students participating in the semi-structured interviews to ensure replicability of the results.

(The items in red are changes that were made between the pretest and final versions)

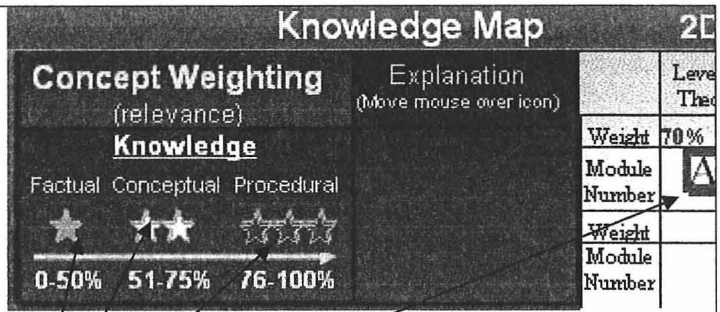
Knowledge Repository Learning System
(The blue colors are usually things you need to try)

Testing Guide	
Step 1: go to link (KL must be upper case) **http://bbnetwork.njit.edu/KL42.php**	
Step 2: Click the button for **CPT 493 outline**	
Step 3: Identify several items on the screen • First look at the box labeled course outline CPT 493. • Use the **scroll bar at right** to look at the course outline Every time you select a course outline for a different course a new course outline will be loaded	

Step 4

There are two knowledge maps: 2D and 3D views.

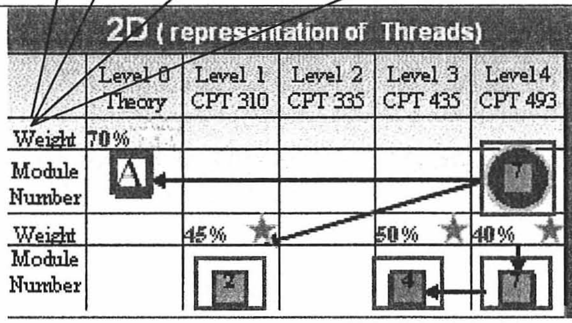
- All the icons (pictures) when you move the mouse over them they describe the information they represent. Try **them**



Step 5

Shows how concepts across multiple courses are linked

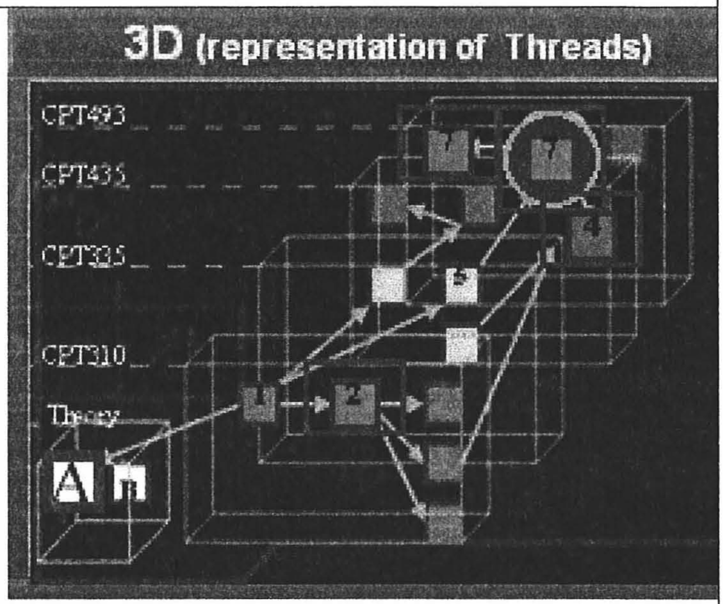
- Each of the boxes represents concepts discussed in the course.
- For example the box with a 2 in the column under CPT 310 is a view graph of a slide in week 2(module 2)
- Click on it and a view graph will appear



Step 6:

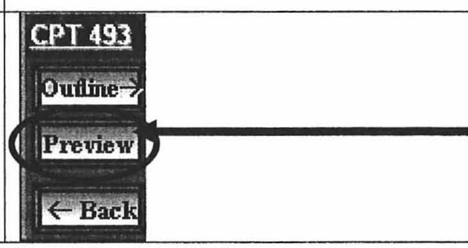
This is a 3D representation of how courses concepts are linked across multiple courses.

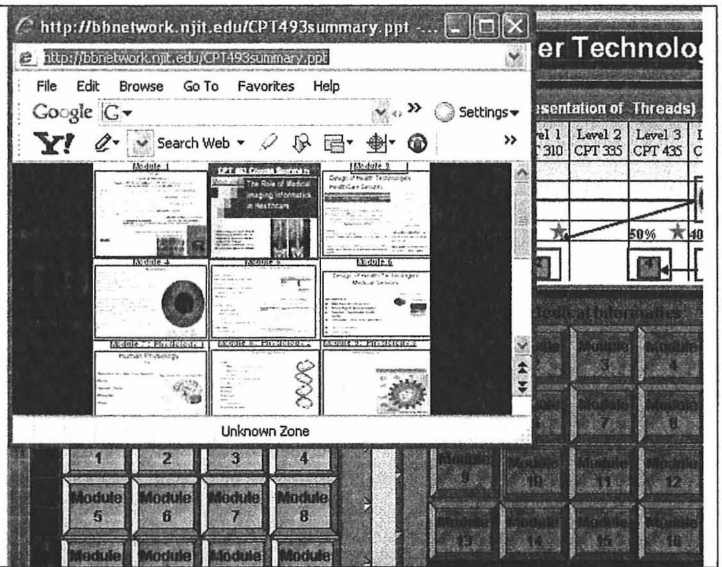
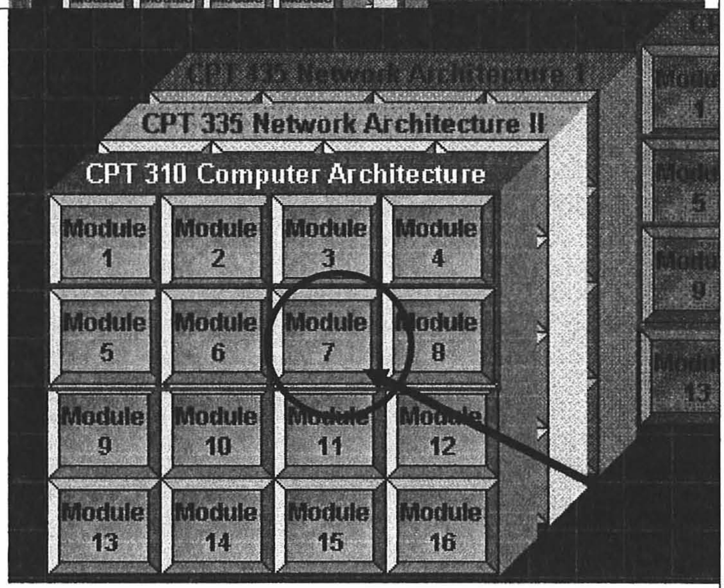
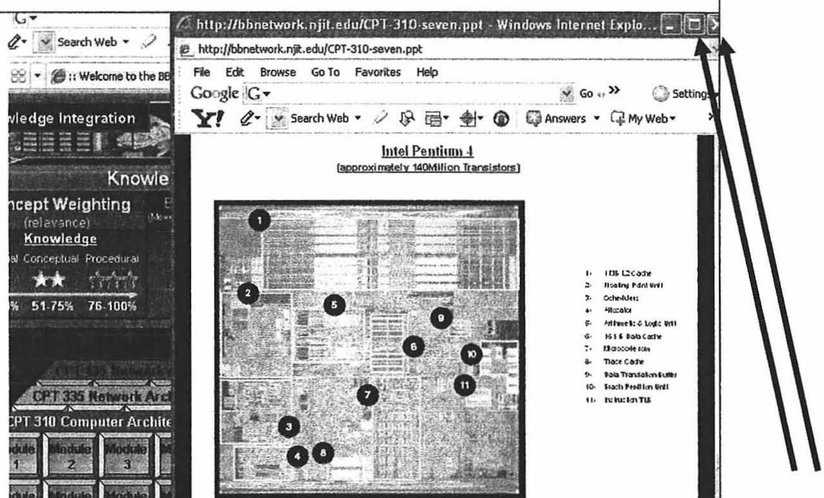
- **All the links can be selected and work showing course slides that illustrate a concept.**
- **Try clicking on a few links**

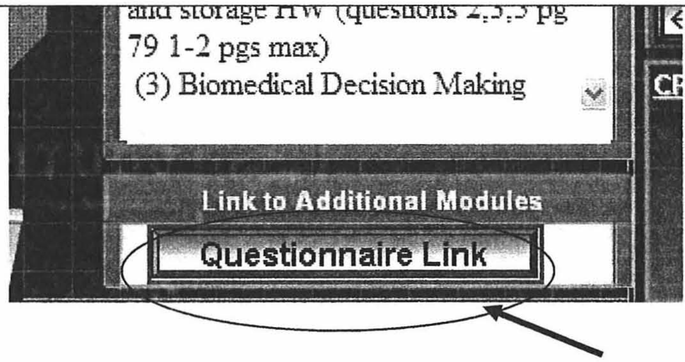


Step 7A:

. Click on the preview button of CPT 493



<u>Step 7B</u>: A window will popup. This is a graphical summary of the lectures. It takes one slide from each module to give you an over view of the course.	
Step 8A: -**Select (click on) at least one course module**, which is a complete course lecture. A popup window will appear -	
Step 8B: -Expand the lecture window to full screen. –Use the right arrow key or page down to step through the lectures. -Then <u>close the popup</u> window using the red X in the right hand corner	

Step 9: -You are finished with the testing phase. **-Select the Questionnaire link** in bottom right hand corner. -This will take you to an on line questionnaire (about 1 minute to load) -Please fill out the questionnaire. -This will only take a few minutes to answer - If you have any trouble ask the instructor there	
Step 10: You are finished. **Thank You** for your help. -You are important in helping us improve how courses are taught. - and one of the first people to use a potentially new system to teach university courses	**Thank You!!**

APPENDIX F

TRANSCRIPTS OF SEMI-STRUCTURED INTERVIEWS

This is a transcript of the questions and answers during the semi-structured interviews.

<u>Transcript Notation:</u>
L = Learner
O = Observer
[ ] = Learner behavior
( ) = Observer interpretation

<u>Color coding</u>:
- I used blue for learner's responses. It was easier to quickly scan and get a feeling for his perceptions.
- I used red to indicate skipped questions. Usually items we had already covered in previous questions.

<u>Probing:</u>
I indented all follow up, probing questions, so I could identify areas I needed more clarification.

<u>Italics:</u>
All questions that were asked are *italicized* and **numbered in bold** for easy identification.

<u>D1: Pretest Questionnaire: E. K.</u>

<u>Perceived Usefulness (main features section, questions 1,2)</u>

O = (Question 1): *How would you describe the presentation of multiple courses/content (notes) in one central location?*

L1: I think it's very useful to see everything in one central location, because it's very useful to see everything in one place, you wouldn't get confused looking for any particular course name. It is all here for you on the same page to look up anything you would want to look for.

> **O = (probing a point he made by asking a follow up question): (Question 1a:) Did it help you learn the material any better?**
>
> L1: I think so, it'll be faster, better, and helpful in many ways. Actually this website is something I have never seen before; everything is here for you, all of the course names, modules, etc.

O= (Question 2): *How would you judge the benefits of the preview page that shows you a graphical overview of the course content?*

L1: I think preview page is just a great way of looking up what the each course is all about for that semester, from the first week of the semester till the fifteenth week of the semester. If a student has any questions for any type of course, he/she can go to preview page to see what it'll be expected in each lecture from module one till module fifteenth. Again, I think it is a great way of showing what the each course is all about.

Perceived Ease of Use (main features section, questions 3,4)

O = (Question 3): *How would you evaluate the screen layout using the cube to represent multiple courses?*

L1: Cubes are a really good way of showing all of the course information listed under each different course name for students to have an easy access to any information they want in a very quick and unique way.

O = (Question 4): *How would you describe the user interface: Is it easy to understand how to use the system?*

L1: Yes, it is very easy to understand how to use the system, knowledge maps really help you as well as 2D and 3D representation of threads help you how to navigate the page as well as the outlines and preview, and looks really good.

Usefulness of the Knowledge Repository (main features section, questions 5,6)

O = (Question 5): *What do you think of the "knowledge map" that links ideas across multiple courses* (finding how concepts evolve from one course to another)?

L1: I think it's a good way of showing with the arrows what is important and what is not. And the color coding helps you to decide and then you can easily go back and forth to find out information from any particular course.

> **O = (probing a point he made by asking a follow up question):**
> **(Question 5a):** What do you think of the 2D version vs the 3D version. Better or worst should you have both?

L1: I think both versions are a good idea, but 3D has an advantage over 2D,

because it shows you a lot more clear, also color coded better then 2D representation.

O = (Question 6*): How would you evaluate the knowledge repository approach of aggregating (combining all the courses notes and links between ideas in one central location (web page)*?

L1: As technology moves on, this is a great way of teaching the computer technology programs, it is a lot more easier, convenient, faster and helpful compared to other computer technology websites that I have seen before. This is an excellent technology website and I hope it'll be very useful to all of computer technology major students.

D2: Final Questionnaire: M. M.

Perceived Usefulness (main features section, questions 1,2)

O = (Question 1): *How would you describe the presentation of multiple courses/content (notes) in one central location?*

L2 = The idea is good. Put all of the information into one central database. We can access it any time we want anywhere you are in the world. It's a good way to refresh your memory if you want to go back to a class you have taken year or two years ago. The idea is really good.

> **O = (probing a point he made by asking a follow up question):**
> **(Question 1a:) Did it help you learn the material any better?**
>
> L2 = It all depends on the student. The information is there but if he/she doesn't want to learn it that his/hers problem. So basically it's the student's responsibility to learn it. If he/she doesn't want to learn nobody can force them to it.

O= (Question 2): *How would you judge the benefits of the preview page that shows you a graphical overview of the course content?*

L2 = Preview page to me it's a good idea. It shows me a minimal idea of what we gone cover in each module/week so I can have a better understanding of what we gone learn.

> **O = (probing a point he made by asking a follow up question):**
> **(Question 2a):Do you think it helps a student understand or see what is going on in the course better or worse than the standard text course outline.**
>
> **L2** = It probably will help because you will be able to see basically ahead what you gone learn so you can researched ahead before the class starts. That's an advantage for the student.

<u>Perceived Ease of Use (main features section, questions 3,4)</u>

O = (Question 3): *How would you evaluate the screen layout using the cube to represent multiple courses?*

L2 = The layout I like. What I would suggest maybe not now but later the webpage, when it looks to automatically fit the screen size resolutions. I would do this for both Pc and portable devices. That would probably be the only thing I would change. Other then that to me it looks good.

> **O = (probing a point he made by asking a follow up question):**
> **= (Question 3a) Can you think of a better way of representing multiple courses?**
>
> **L2** = I think the way it's done now its shows multiple layers its goes form layer 1 to layer 2. So it gives more in depth information.

O = (Question 4): *How would you describe the user interface: Is it easy to understand how to use the system?*

L2 = At first it may be hard for the student to use, but one you use it's not hard. It pretty easy to understand but it will time a couple of tries to get used to it.

> **O = (probing a point he made by asking a follow up question):**
> **(**Question 4a): Is there anything is specific you did not like about how the screen is set-up?
>
> **L2** = If the screen was bigger it would be much better. If the resolutions are low you really not see the whole thing. Other then that the layout is laid out perfectly.

<u>Usefulness of the Knowledge Repository (main features section, questions 5,6)</u>

O = (Question 5): *What do you think of the "knowledge map" that links ideas across multiple courses* (finding how concepts evolve from one course to another)?

L2 = To me that's a helpful hint. Let's say you don't know something it shows you exactly where to go to get information on it. It shows you where you are now and where you have to go later. That a good idea.

> **O = (probing a point he made by asking a follow up question):**

(Question 5a): What do you think of the 2D version vs the 3D version. Better or worst should you have both?

L2 = What I would do is to hind the 2D. I would probably have a button to show the 2D. To me it doesn't not matter 2D or 3D. 3D to me looks much better then 2D. 3D is more graphical then 2D. 2D has more text. For me 2D and 3D would work fine.

O = (probing a point he made by asking a follow up question):
(Question 5b): Do you prefer the 3D version, and maybe hiding the 2D version?

L2 = I prefer 3D version better. We should have settings section for each user. For example when each user logs-in they can select from a list of items what they want to see on their screen. This is one possibility.

O = (probing a point he made by asking a follow up question):
(Question 5c)What do you think if this knowledge map. Will it help you learn and understand what is going on in the courses? Will it be better or worst?

L2 = It shows what is the most important, how much, what you need to know more then the other classes, so you can get a better understanding of the class. Everything is there but if the student doesn't want to learn it nobody can help them.

O = (Question 6*): How would you evaluate the knowledge repository approach of aggregating (combining all the courses notes and links between ideas in one central location (web page)*?

L2 = Have small groups in which they try the web-site. Also ask them questions based on the web-site to see what they think of it. From here see what they have answered, and maybe down the line where the web-site needs to get expanded then try to improve it based on the answers from the questions.

O = (probing a point he made by asking a follow up question):
(Question 6a): Do you think the idea of teaching courses differently where you have all of the information of multiple courses available to you is better or worse way of presenting the information.

L2 = It's a good idea. You have the information in one spot. You don't need to go from site to site because you have all of the information in one central station where everything is there for you.

APPENDIX G

FOCUS GROUP TRANSCRIPTS

These are the transcripts of the Focus Group sessions.

Participant 1:

Y.E.
November 9, 2007
Senior Group Project

Thoughts & ideas about designing a Computer Technology web site for NJIT.

1. First of all, before looking at anything in particular on the website, I would like to mention that the user interface looks very unique compared to other universities computer technology websites. As soon as I look at the website, the way it's designed as in coloring, organization, color coding, instructions, course names, over all the website gives me a good idea on what to look for when I want to find or look for something.

- What I like on user interface is it is very clear what you're looking at, no confusion. Clicking the index buttons to bring the information out for each different course for a better view is a great future.
- **Knowledge map (local)** is good, helpful information provided on the website to tell students what really is important as well as what is least important. Arrows and Stars really help you to visualize and makes it easy to see important and non-important features of this website, as well as the given percentages of course.
- **Knowledge map (global)** is also very helpful for students to follow course information, because it is designed by matching colors and showing of arrows to follow the right path in order to get to the course information any student would like to see.

2. If I were to build this webpage for my BS degree, I would still do something unique like Professor Lubliner is doing. It would really have to be attractive, I would use knowledge maps in order to clear any confusion on the website.

- I would not like the course outline display screen, I would either get rid of that or make it look better in design.

3. You can go into more depth of any course provided within the website. On the select a course column you can click the **Review** button, and open up the power point slide to see all of the modules are listed for that particular course in a semester. It is easy to preview what you will be doing for that course from week one to end within only one page, very convenient and straight forward process.

Note: On the user interface, if it was me, I would replace the **Review** button with a **Preview** button, since it makes more sense about what it is doing.

4. Yes, video clips are very useful to have, where it's necessary on power point slides, I think this is a really good idea since not everyone understands the material verbally, watching the video clips could really be useful and helpful for students to understand the material. Some of students could be good in verbal some could be better in visual so again this is such a good idea to have.

- **Video clips** on portable devices could be a problem, because you would need an internet connection to play the video clips, since most portable computers are connected to the internet via wireless LAN, depending on your connection to a wireless network you might have some difficulty running the video clips.
- Another thing that caught my attention while looking at the video links on power point slides that they are not noticeable and could be presented in a better way to attract more attention.

5. My feelings about organizing information is easier then teaching a particular course, because in organizing, information is already there for you to put it in its organized way, like in categories, shape, subject, etc.

- Both the organization and teaching of information that are posted on the Computer Technology website are so far very educational and needed information, including the way the web page designed, power point information as well as video clips.

6. The general screen lay out is good, except some little wording problems I have mentioned before as **Review** needs to be changed to **Preview**.

- Also the CPT 310 course information is missing the arrows, and back button. The course outline display section could be designed in color and in more fashionable way to attract attention and be able to see well.
- Over all the visual set up I like, except the parts I have mentioned I didn't and thought it could be better design.
- For the course outline display section, you could have a colorful background, maybe a picture and put the writing on top of it with a reasonable coloring.

7. I think **video tutorials** are better way of showing vs. **text tutorial** because, showing a video about a particular subject and visualizing it is always better then seeing it in text. In video tutorials seeing and hearing the information helps you better in understanding the material.

8. Connecting things from course to course is important and useful. One information could always relate refer to or could be about information in another course. Information should have links to each other in order for a quick reference.

Participant 2:

S.E.

1) What would I change if I were to agitate the website?

As far as the layout is concered first I would change the grid background to maybe a more simplifed one for it maybe a plain page with the NJIT logo or something related to Computer Technology like a light contrasted circuit board. By expanding the size of the layout, the modules of the webpage could be efficiently utilized and there would be room for expansion.

2) Likes and dislikes about the site so far.

One dislike about the site so far is a few of the navigation features such as the 'cube access'. When a second cube is 'outlined', it should automatically retract to its 'home' but instead the user would have to manually press 'back' to retract it. One thing I do like about the website so far is the fact that all the access that one would need is located on one page. There is no need to roam through various pages to make use of the webpage

3) Is the use of video clips a bad idea or not?

The use of video clips is actually a great idea. As far as teaching, it can really help a number of students who aren't able to grasp certain concepts by the use of lecture notes alone. Some students prefer to visually note ideas much easier than others. So the use of video clips definately is of great use to a good number of audiences. I personallyfind it more intriguing.

4) Organizing info.

The availability of all the info on this site will greatly benefit a student who is looking for links to all his/her related course work that they have taken (or looking to take) during their time here at NJIT. Rather than going to a few classes early in the semester only to realize that that certain class is not for them, the availability of the course notes will help them decide whether to register or not. It also assists students if they need access to notes for studying.

5) Comments about the UI.

While the UI is structured, some may not find it very user-friendly. I think that just simply zooming the page to fit the entire browser window, navigation can be greatly improved. With the larger size the modules on the page can have their own area to distinguish itself. This change will greatly enhance the site with minor changes to the modules.

6) Opinions about the video tutorial showing users on how to make use of the system.

The video tutorial on the website is a great idea as there may be some students who will have difficulty with the navigation part. One suggestion that I would say is that maybe categorize the tutorial into

2) **Participant 3:**

3) M.M.

1. If you were to design a website to organize all courses information for B.S degree, what would you put in there that would be useful?

If I were to design a web-site I would include the following items

A. Navigation Map
B. Lecture notes
C. Pre-view
D. Video clips
E. Place to exchange information between classmates
F. Add links to external information
G. Links to other classes when additional notes are needed
H. A search engine to find the information quicker and more precise to the point we want it.

These are just a couple of things I would use if I was to design a system for students.

2. Is there anything on the user Interface that does not make sense and what you like and dislike and what might me changed?

I really would not change a lot on the interface. Maybe what I would change would be to change the course outline, to a more and useful interface. Other then that to me the interface looks fine. Maybe when the system goes fully into action then the interface can be changed, because there will be more options on the web-site to choose from.

3. How do you like the idea of having a review of all lectures into a review slide?

I personally like the idea of having a review, because I would be able to see what material I will need to know, and what I will learn when I take that class. The review can also serve as a reference review when we forget something and want to go back and review that material. Instead of going through the entire lecture material notes the material can be found in the review section. The idea of the review section is a really good and it will be useful in the system.

4. Are video clips are good idea or is it not?

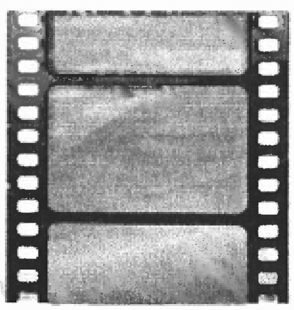
Video clips are really useful in any website. They give another perspective on a particular subject. Some students learn the material faster through video clips rather the from lectures/notes. Video clips give more visual and sound effects compared to notes.

5. Is a video clip a good idea to be used on portable devices?

Since technology is so advanced video clips can be viewed on portable devices. People are on the go all the time and having the ability to see the data on portable devices is a great way to view it. Maybe the quality is not the best as on a regular PC. The fact has to do with the connection. A lan connection is faster than a wi-fi connections. Portable devices now can view different format of video.

6. What should be a logo to show that it's a video clip?

I am enclosing a couple of sample video clip logos



7. You're feeling about organizing/teaching, so you can get more out of it?

Organizing information into one useful system is great. Since I am paying money for my education I want to have access to everything to help me pass and get my degree. If I don't get something when the teacher explains it I can always go and see the information on the web-site. Either read the notes material again or watch some video clips, which will sink into my head. Information that is organized will help the student more that information that is thrown on the web-site.

8. Do you think a video tutorial is a good way to explain the system?

To me a Video tutorial is a good way to explain the system to a user. A video tutorial will show step by step explanation, because not every user grasps the information as quick as another user might. A video Tutorial will also show the user where to find information from the classes that were taken back in the years. It will also show the user where to go to get information on classes that the user will want to take in the future.

9. Do you like the idea of having links which connect to other useful piece of information?

The idea of having links to other information is really useful and sometimes crucial during the 4 years of college. Everyone cannot remembers everything and having links to information that was covered in the earlier years will give the students a way to refresh their mind and also give the student a better idea on how to maybe finished their homework or study for a test.

Participant 4:

B.V.

<u>1.) If I were going to design and use a website to aggregate all course information for your BS degree what would I do?</u>

I would include all the information pertaining to the courses making it accessible to the user. How I would layout the user interface I'm not sure of.

2.) General screen layout the pro's and con's for user interface based on what is seen.

Con's I've had a few problems with the site itself the frame sometimes don't seem to be aligned they will shift over and cover other parts of the site. It was fixed simply refreshing the website. It just may be the resolution on my system.

Pros's Very easy to use interface well thought out easy to navigate. The pop-up widows for accessing the power point slides works well because of the ability to resize them. You can access multiple power points and have those all displayed at once.

3.) Do I think a video tutorial to show you how to use everything would work vs. text tutorial?

I think that a video tutorial would be better than just a simple text tutorial. It isn't something that is done often and will make understanding the site a lot easier for everyone. I would personal use a voice over on it with the text he scrolls the screen.

4.) My feeling about organizing information and teaching so I can learn more.

All the course information being accessible from one place using a very easy to use user interface containing connections from previous and future courses. It would make it easier to study for exams using the knowledge map then being able to use the pop-up widows to open multiple power points.

5.) Layout information for course what do you need? Quick look at course information snapshot about course (Review) change to preview.

I like the idea of the review function it gives a good overview of what contained. It shows more than a course outline as long as the professor places important information from the course in the function it should be very helpful to students looking over courses.

6.) What do I think about having things connected from course to course?

The course connection features could be one of the best features. As long it functional and easy to understand well thought out and implemented. This feature still not useable but I would like to see this function to give better input.

APPENDIX H

HICCS 2008 PAPER: DISSERTATION RESEARCH

The following paper, relating to this research, was presented at the 41st Hawaii International Conference on System Sciences.

Proceedings of the 41st Hawaii International Conference on System Sciences - 2008

N^2 Heads are Better than One: Collaborative Learning, Utilizing an Integrated Knowledge Repository, Facilitated Through a Massively Multiplayer Online Gaming (MMOG) Paradigm

David J. Lubliner, Ph.D. Candidate
New Jersey Institute of Technology
Lubliner@NJIT.edu

George Widmeyer, Ph.D.
New Jersey Institute of Technology
Widmeyer@NJIT.edu

Abstract

A Massively Multiplayer Online Game (MMOG) framework will be utilized to enhance learning in a distributed collaborative learning environment (CLE). The goal is to create a single interconnected learning environment that spans multiple courses. These online courses will share a reusable knowledge repository that contains information relevant to a field of study. We have selected four interrelated network security courses; computer networks, computer security, computer forensics and emergency management to create a self-sustaining interconnected learning environment. This model can then be utilized in other disciplines. A five- level MMOG game will be developed that requires the collaborative skills of students in multiple courses to engage in problem solving scenarios. As the students' knowledge progresses they will be assigned to increasingly higher levels of problem- solving complexity, incorporated into an engaging 3D gaming framework. It is our hypothesis that students will learn faster and develop more complex interdisciplinary skills utilizing an MMOG than the current method of teaching individual separate courses.

1. Introduction

Current online teaching methodologies utilize a single course oriented, stand-alone teaching paradigm utilizing computer mediated communication techniques to facilitate group learning [2][8][22]. The current teaching paradigms for Asynchronous Learning Networks (ALN's) are currently just an extension of the methodologies used in face-to-face (FTF) courses. The next level of evolution in distributed learning is to combine the knowledge of an entire discipline into an integrated collaborative reusable knowledge base that creates a synthesis of the information into a unified whole. It has been hypothesized that "*Ultimately the development of content knowledge bases that integrate content across multiple courses within a degree program is an expected evolution.*" [23] In order to fully utilize the power of new technologies, the internet and enhanced computational and visualization capabilities, new models are necessary to weave together information into a true knowledge repository. It is our hypothesis that presenting course materials with embedded meaning derived from the context of the overall discipline will enhance and accelerate knowledge formation. A second hypothesis is that students' level of understanding and comprehension will be enhanced by using real world examples [16] will be facilitated by the gaming environment. A third hypothesis is that delivering the information in an engaging presentation and collaboration medium will increase time spent using the system [7]. Our fourth hypothesis is that utilizing the framework of a Massively Multiplayer Online Gaming (MMOG) structure to engage the students in successively higher levels of complexity will support the dynamic and evolutionary nature of the overall system design. [1]

This research is important to the research community for several reasons. First, there is currently no existing model to interconnect online courses that share philosophical and technical commonalities, into a collaborative learning environment utilizing a shared knowledge repository. This knowledge repository will allow students from multiple courses to explore information pathways that transcend the scope of individual course topics. The knowledge repository will provide mechanism for them to traverse and explore interconnected conceptual threads. The Constructivist Learning Environment (CLE) emphasizes knowledge construction is based on providing an environment that fosters the learner's process of organizing and integrating information. We expect to provide the framework to facilitate that exploration. Second, the MMOG framework will provide a mechanism to enable enhanced collaboration between students and instructors who occupy multiple levels of conceptual knowledge. A structure of mentors, guides, apprentices etc. embedded in a gaming environment will be focused on solving real world scenarios, utilizing an engaging gaming environment. The goal of this research is to spur exploration into new paradigms for linking asynchronous learning environments and gaming into a dynamic platform to foster learning and individual exploration of knowledge.

The first step in this research was to select a theoretical framework that would support the hypotheses. The Constructivist Learning Environment [4] [11] is an educational framework that hypothesizes that knowledge construction is based on the concept that learners actively construct a knowledge representation in working memory based on eight components. These eight components are active-manipulative, constructive, collaborative, conversational, reflective-critical, contextualized, complex and intentional. These eight components create a structural framework to engage students in meaningful learning.

The second step was to utilize an engaging environment to motivate students to utilize the system. We researched online environments that had the highest level of user engagement and hours spent online [7] [24] which led us to the MMOG gaming environment. The military has also successfully utilized military games in distributed environments [1]. The other important feature of MMOG's was the multilevel collaborative gaming environments that fostered cooperation. These were evident in popular games like RuneScape, GuildWars, Ragnarok, Everquest and Lineage that had player bases up to several million. [10]

Third, we selected a discipline, computer and network security, to test out our hypotheses. We chose four well-defined courses that span introductory to advanced topics to create this knowledge repository. The courses are: Networks, Computer Security, Computer Forensics and Emergency Management. We have collected all the course notes and have the cooperation of the instructors to test our system. A control group will be used to test learning efficacies. Components of the Computer Information Systems Security Professional (CISSP) exam will be used to test the accumulated knowledge, skills and comprehension.

The next part of this paper describes constructivist learning theory, which forms the basis of a learning environment design. The third section of the paper presents 12 design principles for the development of a learning environment that were derived from a review of the literature of on online game design and constructivist learning theory principles. That section also includes five specific research hypotheses about the effectiveness of such a learning environment. This is followed by a description of the general architecture for a proposed online gaming environment that enables meaningful learning. The final section is some conclusions and future plans for this research in progress.

2. Theoretical Framework

There are three approaches to learning that have evolved during the last century: Learning as response strengthening, learning as knowledge acquisition and learning as knowledge construction. [15] The first approach has the learner passively receiving reward and punishments, such as drill and practice, simple response and feedback. The second has students placing new information in long term memory. The learner still passively acquires information from the teacher who presents information in textbooks and lectures. Knowledge is a commodity transmitted from the teacher to the learner. The third approach, learning as knowledge construction, is based on the concept that learners actively construct a knowledge representation in working memory.

In the early 1900's Piaget's theory of cognitive development in children [18] postulated a sequence of four qualitatively distinct stages of intellectual development. Sensor-motor, Preoperational, Concrete operations and Formal operations He believed that "the learner must be active, he is not a vessel to be filled with facts. Learning involves the participation of the learner". Creating an environment designed to allow students to explore and independently navigate tendrils of interconnecting concepts will empower and enhance their construction of more cohesive understanding of interconnected facets of a discipline. Later in the 1900's Vygotsky's [25] *Zone of Proximal Development (ZPD)* stated that the potential for cognitive development depends on social development. Skills that can be developed in collaboration with their peers exceed those which can be attained alone. This supports the hypothesis that gaming can be used to increase social interaction in learning environments and can potentially increase knowledge acquisition. Later in the 1990's theories based on human learning in realistic settings [11] emerged that the learner is the sense-maker and the teacher is the cognitive guide who provides guidance and modeling on authentic academic tasks. The instructional designer's role is to create environments in which the learner interacts meaningfully and fosters the learner's process of organizing and integrating information. The CLE provides a framework for designing and building the third approach.

The goal of CLE's [11] "*is to foster problem solving and conceptual development.*" Objectivist conceptions of learning assume that knowledge is individually constructed and socially co-constructed by learners based on interpretations and experiences in the world. *The goal is to "engage learners in meaning making (knowledge construction)."* [3][26]

The CLE is an education framework that combines eight components to engage students in meaningful learning [4] [11]. This will be used as a structural framework to model the MMOG learning environment. The eight components are:

Active/Manipulative: Learners are engaged by the learning process in mindful processing of information where they are responsible for the result.
Constructive: Learners integrate new ideas with prior knowledge in order to make sense or make meaning or reconcile a discrepancy, curiosity, or puzzlement.
Collaborative: Learners naturally work in learning and knowledge building communities, exploiting each other's skills while providing social support and modeling and observing the contributions of each member.
Conversational: Learning is inherently a social, dialogical process [6]. That is, given a problem or task, people naturally seek out opinions and ideas from others.
Reflective/Critical: Learners should be required by technology-based learning to articulate what they are doing, the decisions they make, the strategies they use, and the answers that they found.
Contextualized: A great deal of recent research has shown that learning tasks that are situated in some meaningful real world task or simulated in some case-based or problem-based learning environment are not only better understood, but also are more consistently transferred to new situations.
Complex: Teachers may often oversimplify ideas in order to make them more easily transmittable to learners. In addition to stripping ideas out of their normal contexts, we distill ideas to their simplest form so that students will more readily learn them.
Intentional: All human behavior is goal directed [29]. That is, everything that we do is intended to fulfill some goal.

3. Design Principles

The intent of this research is to integrate facets of gaming paradigms with constructivist learning theory to facilitate knowledge construction. A recent study [28] of 30,000 online gamers in an MMOG environment analyzed five factors motivating users: Achievement, Relationships, Immersion, Escapism and Manipulation. The data indicates that users derived real-life leadership skills from these virtual environments. These complex environments may currently be classified as games but their complexity and the evolving skills derived from navigating these virtual worlds can lead to richer learning environments.

The literature on gaming [1] [7] [13] suggests that more than 60% of the U.S. population ages 12-22 is engaged in some form of gaming. The percentage is higher for males with 75% of males in this age group being engaged in some form of gaming at least once a week. Approximately 37% of individuals in this age group were found to play up to eight hours a week. This seems to indicate that if we can harness the unique features that engage individuals and apply it to learning environments we can increase interest and possibly knowledge acquisition in conventional university curricula. MMOG's research [10] indicates that features that make these games attractive are players achieving milestones, accessing new weapons and tactics, taking on increasingly challenging opponents and obstacles and assuming different roles and identities. This is in contrast to single player games that revolve around shooting and killing.

A book by Gee [7] argues that good video games produce better learning conditions than many of today's schools. The book presents 36 learning principles that should be considered in using games when designing a learning environment. Ten of these principles were adopted by Bonk and Dennen [1] as being particularly pertinent to MMOG's. A review of both sets resulted in a revision to some of the Bonk and Dennen [1] principles, and the addition of three new ones (numbers 1, 2 and 3 below). The resulting 12 design principles for a CLE are:

1) **Engaging Principle**: The game must have a compelling theme that is attractive to potential users.
2) **User Interface Ease of Use Principle**: The text and environment should be of the appropriate size and have intuitive controls.
3) **On-Demand and Just-in-Time Tutorial Principle**: Instead of reading dozens of pages on how to use the game, tutorial should be part of the game.
4) **Achievement Principle**: Learners should be constantly rewarded, at each level of the game play and skill mastery.
5) **Amplification of input Principle**: Learners should get out of the experience more than they put in.
6) **Distributed Principle**: Learners should find growth and knowledge in their interactions with other learners, technology, context, objects and tools.
7) **Multiple routes Principle**: There should be more than one way for users to progress, encouraging them to make decisions and solve problems.
8) **Practice Principle**: Learners should be able to spend a lot of time practicing in an interesting environment.
9) **Psychosocial Moratorium Principle**: Learners should be able to take risks in artificial environments where there is **a lower chance of real world consequences.**
10) **Regime of Competence Principle**: Learners should be challenged to push beyond their comfort / ability zone, but not to an extent that is unsafe or unattainable.
11) **Self Knowledge Principle**: Players learn about themselves and their current and potential capabilities.
12) **Collective knowledge Principle**: Players learn from other players' experiences, building a repository of useful knowledge shared by all.

4. Validating the Design Principles

There are two questions that need to be explored. The first is whether the 12 design principles are consistent with a learning environment based on constructivist learning principles. The second is determining the most appropriate architecture of an online game that is specifically designed as learning environments. We discuss the first question in this section and the second question is addressed in the following section. The first validation is done by comparing the 12 design principles to the constructs in a survey that has been used to test student's preferences for a learning environment based on constructivist principles.

The original version of the Constructivist Learning Environment Survey (CLES) was introduced in 1991, but it was later significantly revised and retested. Each scale of the new version of the CLES is designed to obtain measures of students' perceptions of the frequency of occurrence of five key dimensions of a critical constructivist learning environment [21]. The Constructivist Multimedia Learning Environment Survey (CMLES) starts with the CLES, but was modified to better reflect the characteristics of a learning environment that uses interactive multimedia technology. Each scale of the CMLES is designed to obtain measures of students' perceptions of the frequency of occurrence of five key dimensions of a critical constructivist learning environment. The CMLES contains 25 items altogether, with five items in each of five scales. The response alternatives for each item are Almost Always, Often, Sometimes, Seldom, and Almost Never. The five scales are: Student Negotiation, Inquiry Learning, Reflective Thinking, Authenticity, and Ease of Use [14]. We have modified the instrument slightly to produce the CGLES.

The Constructivist Multimedia Learning Environment Survey [14] [21] has been validated in several research studies of high school science and mathematics classrooms and has been used in various studies in different countries. The Maor Survey has been used in the classroom and in a teacher development program. Table 3 shows descriptive information for each of the five scales for a survey we call the Constructivist Gaming Learning Environment Survey (CGLES). We are planning to use this survey to gather information

Table 3. Descriptive Information for each Scale of the CMLES (adapted from Maor [14])

Scale Name	Description	Sample Item
Social Negotiation	Extent to which students have the opportunities to discuss their questions and solutions to questions	In the game-based learning environment, I prefer that I can ask other students to explain their ideas.
Inquiry Learning	Extent to which students are encouraged to engage in inquiry learning	In the game-based learning environment, I prefer that I can carry out investigations to test my own ideas.
Reflective Thinking	Extent to which students have opportunities to reflect on their own learning and thinking	In the game-based learning environment, I prefer that I can think critically about my own understanding.
Authenticity of the Learning	Extent to which the information in the game is authentic and representative of real life situations	In the game-based learning environment, I prefer that I work with situations that are relevant to me.
Complexity of the Learning Environment	Extent to which the game playing environment is user friendly and easy to navigate	In the game-based learning environment, I prefer that the game space is easy to navigate.

about student's preferences for a game-based learning environment.

5. Hypotheses

The overall hypothesis of our research is that students will learn faster and develop more complex interdisciplinary skills utilizing an MMOG with an integrated knowledge repository then the current method of teaching individual, separate courses. The main question of our current research is how to design online games that satisfy the 12 design principles. We are exploring just five of the principles at this stage of the research.

The Engaging Principle states that the game must have a compelling theme that is attractive to potential users. It's our hypothesis that students will learn more effectively in an interactive 3D environment that provides users with interactive scenarios that allow them to select navigation paths and game scenarios to reinforce the information presented.

H1: Students using a MMOG learning environment will prefer a game over a class and be more engaged in learning than students in conventional on-line teaching courses.

The Collective Knowledge Principle states that players learn from other players' experiences, building a repository of useful knowledge shared by all. In conventional courses students are limited to the information presented from a single perspective of the discipline. By combining the integrated knowledge of the entire discipline with the ability of students to collaborate from multiple perspectives, i.e. computer security or computer forensics, the students will gain a richer experience.

H2: Integrating multiples courses into a collective learning environment will increase students' knowledge of the interconnected nature of the discipline as opposed to single topic courses.

The Distributed Principle states that learners should find growth and knowledge in their interactions with other learners, technology, context, objects and tools. Learning is enhanced when students share knowledge and solve problems collectively rather than sit passively and absorb information from lectures. The MMOG environment will provide interactive gaming scenarios to allow students to research and solve problems collectively in an engaging learning environment.

H3: Students engaged in a MMOG gaming environment will develop better collaboration skills than those students in conventional courses.

The Amplification of Input Principle states that learners should get more out of the experience than they put in. By allowing students to independently navigate the integrated knowledge base, they can control the pace and nature of information gathered. Each of us learns differently and at a different pace. Providing students with an environment that allows them to tailor their own learning experience should enhance knowledge absorption.

H4: Students will learn faster in an MMOG than students in a conventional course.

The Regime of Competence Principle states that learners should be challenged to push beyond their comfort / ability zone, but not to an extent that is unsafe or unattainable. Students will explore and navigate the environment if they are challenged. Online games have proven that if they are properly engaged, individuals will spend significant hours exploring interesting visual interactive environments.

H5: Courses taught in a collaborative environment will be more up-to-date than conventional stand alone courses due to the feedback of other instructors and students.

6. Learning Reinforcement Model

In order to integrate knowledge that spans an entire discipline, there has to be a well defined model to integrate the individual course topics. Common elements that exist between the materials, correlation weights, interdependence of variables and the relevance of existing and new material will provide the correlation matrix used to evaluate concept interdependencies. This will evolve over time as new theories appear and the increasing volume of quantitative evidence supporting those claims is presented in refereed journals. One measure of field relevance could be the number of citations of a particular concept or approach.

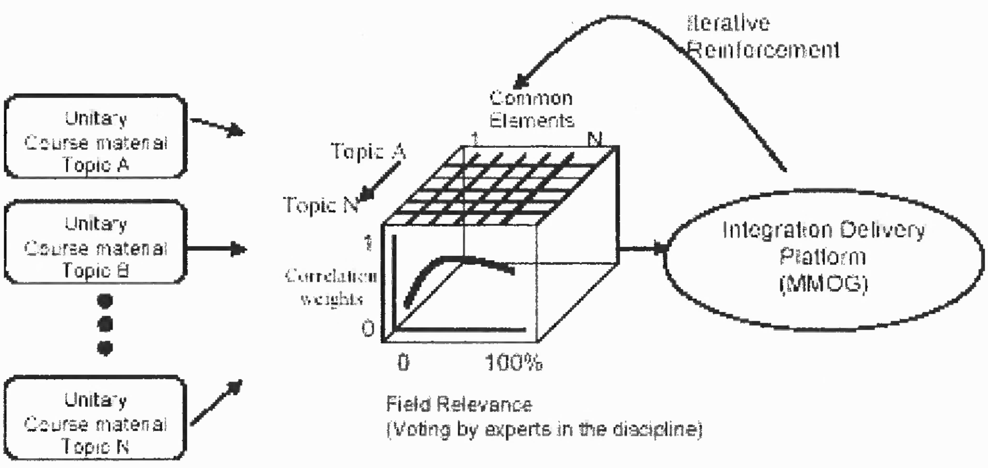


Fig. 2: Learning Reinforcement Model

7. Experimental Design

The design and testing of the Knowledge Repository (KR) and the MMOG gaming levels will be completed in three stages. The first stage, the Knowledge Repository, Level I & II of figure 1, with 3D user interface has been constructed and is currently undergoing prototype testing. An authoring tool has been developed to facilitate entering course materials into the system. Using this web based tool six classes, approximately 150 students, will utilize this tool. Learning experiences will be evaluated using the Constructivist Multimedia Learning Environment Survey (CMLES) [14] in

October/November 2007. The constructs evaluated in the CMLES survey are summarized in table 3. They include reflective thinking, complexity of the learning environment, authenticity of the learning environment and social negotiation. These design principles will be evaluated to determine the most/least effective aspects of this design. Data will be available to present to the HICSS conference. Cronbach's Alpha will be performed to confirm the internal reliability for questions relating to each of the above CMLES constructs. Factor analysis will be run to confirm any relationships. The second stage, integrating the MMOG gaming level III, will utilize the Active-Worlds Educational Universe (AWEDU) [27] MMOG design software. This component is currently under development and it is anticipated that this level will be integrated with the Knowledge Repository in fall 2007.

This system integrates the content material of four computer/network courses with an intuitive 3D interface which will allow students to navigate material transcending any one particular course of study.

Stage three will entail testing the system, spanning multiple universities, in a truly MMOG environment.

8. Designing the MMOG

Massively Multiplayer Online Games are built around the idea of connecting individuals together in a virtual space. These teams create shared situational awareness through the sharing of information and through goal-directed collaboration [1]. They also cut across hierarchical lines by allowing individuals and groups to achieve a degree of self-synchronization. MMOG's provide users with the ability to interact with other individuals anywhere on the planet.

The success of a number of MMOG's has engaged thousands of users worldwide and provides a tantalizing hint at the potential application of these gaming environments. Some of the popular MMOG's are Anarchy Online, Lineage, Asheron's Call 2, Ever Quest, Ultima Online, and Dark Age of Camelot. Lineage has 2.5 million subscribers [24]. EverQuest has 350,000 players with 100,000 simultaneous players and Ultimate II has had up to 14,000 simultaneous users [12]. It has been estimated that 60% of the U.S. population has played some level of computer game [13].

The current effort in this research in progress is to work with four professors to integrate four security courses – networks, computer security, forensics, and emergency management – to create the core database and learning materials to create an integrated knowledge base for a single online game that can be used across all four courses. The MMOG learning environment will be structured around five levels of increasing complexity. The first three levels are illustrated in Figure 1.

The CLES states that knowledge is individually constructed and socially *co-constructed by learners* based on interpretations and experiences in the world [11]. The MMOG will integrate CLES goals of socially constructing knowledge by providing a gaming framework that fosters information sharing between students at various skill levels. This is facilitated by constructing gaming groups consisting of students from multiple skill levels, i.e. beginner through advanced. This skill level is determined by the system providing quizzes that rate knowledge acquisition by their proficiency on these exams. Their ranking will be scaled from 1-100. All gaming scenarios will randomly select students from different course and skill levels to ensure a heterogeneous game population, i.e. a learning environment that provides mentors and novices interacting in problem solving scenarios. At the start and end of each game scenario, i.e. resolving a particular security threat, they will take a brief proficiency test to measure the efficiency of this approach.

Figure 1 illustrates the integration of the CLES knowledge repository, level 1, with the gaming level III. Level 2 utilizes a WebCt environment that provides discussion forums, mediated by instructors that enable cross course discussions. Students will begin with conventional course materials. Embedded in them will be links to the knowledge repository. They will have the option to explore related concepts displayed as a vector diagram that displays concepts in the form A → B → C → D. Concept A would normally be covered in course 1, B in a more advanced course, etc. Students will have the ability to explore the topic in any depth. A new Learning Reinforcement Model (LRM), figure 2, will link together concepts based on correlation weights.

10. References

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APPENDIX I

QUANTITIVE EXAM

The following questions encompassed the quantitative exam designed to test participants level of knowledge about the content as it was presented using either conventional teaching methods or the CUBE System.

Questions (CASE Study): Circle the correct answer
Check the courses you have completed

☐ CPT 310 ☐ CPT 335 ☐ CPT 435 ☐ CPT 493

☐ Check box if you used the CUBE online tutorial

☐ Check the box if you are not a CPT Major IF checked type in Major --------------------

---

1) How much faster/slower are disk drives than solid state memory?

10 100 1000 1,000,000

2) Where is L2 cache located?

External to the CPU Internal to the CPU Neither

3) What type of CPU uses L3 Cache?

Pentium Dual core CPU Quad core CPU

4) Why are L2 and L3 cache used?

Extra Memory Speed up CPU operations neither

5) Why is the Brach prediction unit used?

Save time Save memory Load future branches into L2 cache

6) How much time does the BPU save over CPU's without this feature?

10% 25 % 50 % 75 % 90% 100%

7) What is the purpose of pipelines?

Data storage Memory management have all steps for the process available

8) Whose pipeline is longer?

Intel AMD Same size

9) What is the process of making CPU's on a Chip?

Photography Photolithography Built by robots

10) What are the current sizes of templates used for making microprocessors?

A thousandth of a meter A millionth of a meter A billionths of a meter

APPENDIX J

SEMANTIC WEB / RANKINGS

•**Definition:** "The Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries. It is a collaborative effort led by W3C with participation from a large number of researchers and industrial partners. It is based on the Resource Description Framework (RDF).

•The semantic web is composed of a set of design principles XML Schema, RDF(Resource Description Language), OWL(Web Ontology Language) and working groups, a group of experts in a particular field. (An ontology is a representation of a set of concepts within a domain and the relationships between those concepts: they include classes, attributes, and relationships)

•The goal is to generate a concept space to facilitate the standardization of terms relevant to a knowledge domain.

•**Resource Description Framework (RDF)** is a family of World Wide Web Consortium (W3C) specifications.

•The RDF metadata model is based on the concept of making statements about Web resources in the form of subject-predicate-object expressions, called *triples*

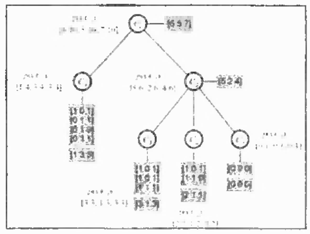
•Utilizing the W3C RDF Vocabulary Description Language RDF Schema this research will utilize a subset to develop a vocabulary and triples for the Computer Technology courses utilized in this research that can then be extended to create a concept space utilized by other programs.

RDF Properties (utilized) W3C RDF Schema			
Property Name	**Comment**	**Domain**	**Range**
rdfs:label	human-readable name for the subject.	rdfs:Resource	rdfs:Literal
rdfs:domain	A domain of the subject property	rdf:Property	rdfs:Class
rdf:subject	The subject of the subject RDF statement	rdf:Statement	rdfs:Resource
rdf:predicate	The predicate of the subject RDF statement.	rdf:Statement	rdfs:Resource
rdf:object	The object of the subject RDF statement	rdf:Statement	rdfs:Resource

Semantic Web (Weighting/voting)

•Students generate links associated with semantic term associated to the lectures.

•Students vote on their perception of the content of each link based on several categories(based on Blooms Revised Taxonomy)



Composite Score

- •Quality of Factual Knowledge (elements students must know)
- •Conceptual Knowledge (relationships among elements)
- •Procedural knowledge (Algorithms and skills)

•They are clustered using concept clustering for each generated class using a COBWEB data structure where each node represents the top five highest ranked composite score.

Week 2

	top 5 sites	Excellent	Very Good	No Opinion	Bad	very Bad
1	http://computer.howstuffworks.com/computer-memory.htm	X				
2	http://www.patentstorm.us/patents/6332191-claims.html		X			
3	http://arstechnica.com/articles/paedia/cpu/core.ars/7			X		
4	http://www.eng.umd.edu/~nsw/ench250/number.htm			X		
5	http://en.wikipedia.org/wiki/Gray_codec			X		

Week 3

	top 5 sites	Excellent	Very Good	No Opinion	Bad	very Bad
1	http://www.iit.edu/~noahlan/index_over.html	X				
2	http://arantxa.ii.uam.es/~jlara/investigacion/ecomm/electronica/comb.html		X			
3	http://academic.evergreen.edu/projects/biophysics/technotes/program/2s_comp.htm	X				
4	http://hyperphysics.phy-astr.gsu.edu/hbase/electric/elevol.html			X		
5	http://publib.boulder.ibm.com/infocenter/systems/index.jsp?topic=/com.ibm.aix.commadmn/doc/commadmndita/asynch_params_parity.htm			X		

Rankings / Voting for CPT 435

	Semantic Terms	Top Five Links	Ranking			
1	*key words*	*link*	Rating one			
2	NW use complex SW		Factual (basic elements)	Conceptual (relationship between elements)	Procedural (overall)	Average
3	network communication exchanging messages	http://en.wikipedia.org/wiki/Computer_networks	90	87	92	90
4	sub-pieces, protocol suites	www.protocols.com/	85	83	84	84
5	protocol design	www.protocol-online.org/	84	80	79	81
6	seven layer	www.xmpp.org/protocols/	83	79	80	81
7	stacks layered SW	www.w3.org/Protocols/	77	75	73	75
8	layered saw,					0
9	nested headers					0
10	layering					0
11	techniques protocols					0
12	out-of-order delivery					0
13	sequencing, eliminate duplicate packets					0
14	retransmitting lost packets					0
15	avoiding replay coursed by excessive delay					0
16	flow control to prevent data overrun					0
17	mechanism to avoid new congestion					0
18	protocol design					0
19		en.wikipedia.org/wiki/Internetworking	99	98	99	99
20	internetworking	www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/index.htm	98	97	98	98
21	universal service	www.careerkey.com/	90	90	90	90
22	universal service	www.internetworker.net/	85	85	85	85
23	internetworking	www.internettg.org/newsletter/newsletter.html	75	75	75	75
24	physical new connection					0
25	internet architecture					0
26	achieving universal service					0
27	virtual new					0
28	protocols internetworking					0
29	internetworking TCP/IP					0
30	layering TCP/IP					0
31	Host Computers, Routers, Protocol Layers					0

33	Addresses, Virtual, Internet	http://en.wikipedia.org/wiki/Internet_Protocol	98	98	98	98
34	IP Addressing Scheme	en.wikipedia.org/wiki/IP_address	98	97	97	97
35	IP Address Hierarchy	www.ralphb.net/IPSubnet/	95	98	98	97
36	Original Classes IP Addresses	searchwindevelopment.techtarget.com/sDefinition/0,,sid8_gci21	90	90	90	90
37	ComputingClass Address	www.lawrencegoetz.com/programs/ipinfo/	85	85	85	85
38	Dotted Decimal Notation					0
39	Classes Dotted Decimal Notation					0
40	Division Address Space					0
41	Authority Addresses					0
42	Glassful Addressing Example					0
43	Subnet Classless Addressing					0
44	Address Masks					0
45	CIDR Notation					0
46	CIDR Address Block Example					0
47	CIDR Host Addresses					0
48	Special IP Addresses					0
49	NW Address					0
50	Directed Broadcast Address					0
51	Limited Broadcast Address					0
52	This Computer Address					0
53	Loopback Address					0
54	Special IP Addresses					0
55	Berkeley Broadcast Address Form					0
56	Routers IP Addressing Principle					0
57	Multi-Homed Hosts					0
58						0
59	Protocol Addresses Packet Delivery	www.ait.unl.edu/siau/mgmt457/chapter17.ppt	99	99	99	99
60	Address Resolution	msdn.microsoft.com/library/en-us/dnppcgen/html/nw_pocket_tra	85	85	85	85
61	Address Resolution Techniques	cs.baylor.edu/~donahoo/practical/CSockets/PracticalSocketC.p	83	83	83	83
62	Address Resolution With Table Lookup	www.cse.ohio-state.edu/cgi-bin/rfc/rfc1208.html	81	81	81	81
63	Address Resolution With Closed-Form Computa	rfc.net/rfc1208.html	75	75	75	75
64	Address Resolution Message Exchange					0
65	Address Resolution Protocol					0
66	ARP Message Delivery					0
67	ARP Message Format					0
68	Sending An ARP Message					0
69	Identifying ARP Frames					0
70	Caching ARP Responses					0
71	Processing Incoming ARP Message					0
72	Layering, Address Resolution, Protocol Addresses					0
72	Layering, Address Resolution, Protocol Addresses					0
73						0
74	Connectionless Service	http://www.inetdaemon.com/tutorials/internet/ip/datagrams.shtm	99	98	97	98
75	Virtual Packets	www.tcpipguide.com/free/t_IPDatagramGeneralFormat.htm	95	95	95	95
76	IP Datagram	www.inetdaemon.com/tutorials/internet/ip/datagrams.shtml	90	91	91	91
77	Forwarding IP Datagram	en.wikipedia.org/wiki/IPv4	85	85	85	85
78	IP Addresses, Routing Table Entries	tools.ietf.org/html/rfc1149	80	80	80	80
79	Mask Field, Datagram Forwarding					0
80	Next-Hop Addresses					0
81	Best-Effort Delivery					0
82	IP Datagram Header Format					0
83						0
84	Datagram Transmission Frames	http://www.cisco.com/en/US/tech/tk827/tk369/technologies_whi	99	99	99	99
85	Encapsulation	rfc.net/std5.txt	95	95	95	95
86	Transmission Across Internet	ftp://ftp.rfc-editor.org/in-notes/rfc4824.txt	90	90	90	90
87	MTU, Datagram Size, Encapsulation	www.netbook.cs.purdue.edu/othrpags/ch20.htm	85	85	85	85
88	Reassembly	www.faqs.org/rfcs/rfc1149.html	80	80	80	80
89	Identifying Datagram					0
90	Fragment Loss					0
91	Fragmenting A Fragment					0
92		www.ipv6.org	99	99	99	99
93	The Success IP	us.ntt.net	95	95	95	95
94	The Motivation For Change	en.wikipedia.org/wiki/IPv6	90	92	90	91
95	Name, Version Number	www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/ipv6.htm	85	85	85	85
96	IPv6 Features	www.ipv6.com/	80	80	80	80
97	IPv6 Datagram Format					0
98	IPv6 Base Header Format					0
99	How IPv6 Handles Multiple Headers					0
100	Fragmentation, Reassembly, And Path MTU					0
101	The Purpose Of Multiple Headers					0
102	IPv6 Addressing					0
103	IPv6 Colon Hexadecimal Notation					0
104		en.wikipedia.org/wiki/Internet_Control_Message_Protocol	99	99	99	99
105	Best-Effort Semantics Error Detection	www.ietf.org/rfc/rfc0792.txt	92	95	98	95
106	Internet Control Message Protocol	www.networksorcery.com/enp/protocol/icmp.htm	93	94	97	95
107	ICMP Message Transport	support.microsoft.com/kb/170292	86	88	87	87
108	Using ICMP Messages To Test Reach ability	ftp://ftp.isi.edu/in-notes/rfc2463.txt	80	86	84	83
109	Using ICMP To Trace A Route					0
110	The Last Address Printed By Trace route					0
111	Using ICMP For Path MTU Discovery					0

112		en.wikipedia.org/wiki/User_Datagram_Protocol	99	96	94	96
113	The Need For End-To-End Transport Protocols	www.ietf.org/rfc/rfc768.txt	90	96	98	95
114	The User Datagram Protocol	www.networksorcery.com/enp/protocol/udp.htm	88	89	87	88
115	The Connectionless Paradigm	compnetworking.about.com/od/networkprotocols/l/aa071200a.htm	84	85	88	86
116	Message-Oriented Interface	www.webopedia.com/TERM/U/User_Datagram_Protocol.html	81	83	84	83
117	UDP Communication Semantics					0
118	Arbitrary Interaction					0
119	Support For Uncast, Multicast, And Broadcast					0
120	Endpoint Identification With Protocol Port Numbers					0
121	UDP Datagram Format					0
122	The UDP Checksum And The Pseudo Header					0
123	UDP Encapsulation					0
124		en.wikipedia.org/wiki/Transmission_Control_Protocol	98	94	99	97
125	The Need For Reliable Transport	www.faqs.org/rfcs/rfc793.html	97	95	92	95
126	The Transmission Control Protocol	www.networksorcery.com/enp/protocol/tcp.htm	86	89	90	88
127	The Service TCP Provides To Applications	compnetworking.about.com/od/tcpip/TCPIP_Transmission_Control_Protocol_I	87	74	77	79
128	End-To-End Service And Datagram's	tools.ietf.org/html/rfc793	72	75	75	74
129	Achieving Reliability					0
130	Packet Loss And Retransmission					0
131	Adaptive Retransmission					0
132	Comparison Of Retransmission Times					0
133	Buffers, Flow Control, And Windows					0
134	Three-Way Handshake					0
135	Congestion Control					0
136	TCP Segment Format					0
137						0
138	The Requirement For Unique Addresses	en.wikipedia.org/wiki/Network_address_translation	99	98	99	99
139	Network Address Translation Technology	computer.howstuffworks.com/nat.htm	97	95	96	96
140	NAT Topology	www.vicomsoft.com/knowledge/reference/nat.html	91	92	94	92
141	Possible Implementations Of NAT	www.openbsd.org/faq/pf/nat.html	90	92	91	91
142	Basic Address Translation	www.openbsd.org/faq/pf/nat.html	88	82	84	85
143	Translation Table					0
144	NAPT And TCP Splicing					0
145	Other Variants: Twice NAT And CAT					0
146	NAT Software And Systems For Use At Home					0

170		http://penguin.dcs.bbk.ac.uk/academic/networks/application-lay	99	95	94	96
171	The Functionality Application Software Provides	en.wikipedia.org/wiki/Client-server	93	91	92	92
172	The Functionality An Internet Provides	www.faqs.org/faqs/client-server-faq/	88	87	82	86
173	Making Contact	www.vitus.com/vfpcs.html	79	81	80	80
174	The Client-Server Paradigm	www.webopedia.com/TERM/C/client_server_architecture.html	77	75	76	76
175	Characteristics Of Clients And Servers					0
176	Server Programs And Server-Class Computers					0
177	Requests, Responses, And Direction Of Data Flow					0
178	Transport Protocols and Client-Server Interaction					0
179	Multiple Services On One Computer					0
180	Identifying A Particular Service					0
181	Multiple Copies Of A Server For A Single Service					0
182	Dynamic Server Creation					0
183	Transport Protocols And Unambiguous Comm.					0
184	Connection-Oriented And Connectionless Transport					0
185	A Service Reachable Through Multiple Protocols					0
186	Complex Client-Server Interactions					0
187	Interactions And Circular Dependencies					0
188	Procedures Implement Socket API	affix.sourceforge.net/affix-doc/x384.html	95	97	99	97
189	Socket Procedure	en.wikipedia.org/wiki/Berkeley_sockets	92	94	91	92
190	Close Procedure	java.sun.com/j2se/1.4.2/docs/api/java/net/Socket.html	71	72	75	73
191	Bind Procedure	publib.boulder.ibm.com/iseries/v5r1/ic2924/info/apis/unix8.htm	65	68	64	66
192	Listen Procedure	msdn2.microsoft.com/en-us/library/ms740673(VS.85).aspx	56	54	55	55
193	Accept Procedure					0
194	Connect Procedure					0
195	Send, Send to, And Sends Procedures					0
196	Revco, Recvfrom, Recvmsg Procedures					0
197	Read Write Sockets					0
198	Other Socket Procedures					0
199	Sockets, Threads, Inheritance					0
200		en.wikipedia.org/wiki/Client-server	99	98	95	97
201	Connection-Oriented Communication	searchnetworking.techtarget.com/sDefinition/0,,sid7_gci211796,	93	91	90	91
202	An Example Service	www.sei.cmu.edu/str/descriptions/clientserver_body.html	85	88	87	87
203	Command-Line Arguments Example Programs	www.faqs.org/faqs/client-server-faq/	77	75	70	74
204	Sequence Of Socket Procedure Calls	www.techsoup.org/learningcenter/networks/page4773.cfm	70	69	72	70
205	Code Example Client					0
206	Code Example Server					0
207	Stream Service And Multiple Revco Calls					0
208	Socket Procedures And Blocking					0
209	Size The Code And Error Reporting					0
210	Example Client Another Service					0
211	Using Another Client Test Server					0
212		en.wikipedia.org/wiki/Domain_Name_System	97	95	99	97
213	Structure Of Computer Names	www.dns.net/dnsrd/	92	94	93	93
214	Geographic Structure	www.internic.net/faqs/authoritative-dns.html	89	88	90	89
215	Domain Names Within Organization	searchnetworking.techtarget.com/sDefinition/0,,sid7_gci213908,	87	81	82	83
216	Domain Names That Begin With www	www.domainnamesystems.com/	75	79	80	78
217	The DNS Client-Server Model					0
218	The DNS Server Hierarchy					0
219	Server Architectures					0
220	Locality Reference Multiple Servers					0
221		ieeexplore.ieee.org/iel5/498/3989/00152689.pdf	99	95	96	97
222	The Electronic Mail Paradigm	www.ieee.org/	91	92	90	91
223	Electronic Mailboxes And Addresses	www.computer.org/	85	84	88	86
224	Electronic Mail Message Format	standards.ieee.org/	81	83	80	81
225	Carbon Copies	en.wikipedia.org/wiki/IEEE	75	79	78	77
226	Multipurpose Internet Mail Extensions					0
227	E-mail Application Programs					0
228	Mail Transfer					0
229	The Simple Mail Transfer Protocol					0
230	Optimizing Multiple Recipients Computer					0
231	Mail Exploders, Lists, Forwarders					0
232	Mail Gateways					0
233	Automated Mailing Lists					0
234	Mail Relays And E-mail Addresses					0
235	Mailbox Access					0
236	Dialup Connections POP					0

APPENDIX K

SAS RESULTS UTILIZED IN CHAPTER 5

The following tables and graphs were generated by SAS software, version 9.1, and represent the complete data analysis that were summarized in Chapter 5.

SAS 9.1 analysis of: CMLES Presentation Questions 58-61

Q58	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Excellent	22	27.16	22	27.16
good	18	22.22	40	49.38
no opinion	7	8.64	47	58.02
poor	2	2.47	49	60.49
very good	32	39.51	81	100.00

Q59	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Excellent	26	32.10	26	32.10
good	19	23.46	45	55.56
no opinion	5	6.17	50	61.73
no positive benefit	1	1.23	51	62.96
very good	30	37.04	81	100.00

Q60	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Excellent	23	28.40	23	28.40
good	22	27.16	45	55.56
no opinion	7	8.64	52	64.20
no positive benefit	1	1.23	53	65.43
poor	3	3.70	56	69.14
very good	25	30.86	81	100.00

Q61	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Excellent	21	25.93	21	25.93
good	27	33.33	48	59.26
no opinion	3	3.70	51	62.96
poor	1	1.23	52	64.20
very good	27	33.33	79	97.53
very poor	2	2.47	81	100.00

SAS 9.1 analysis of: CMLES Content Integration Questions 62-67:

Q63	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Excellent	39	48.15	39	48.15
good	16	19.75	55	67.90
no opinion	3	3.70	58	71.60
very good	23	28.40	81	100.00

Q64	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Excellent	32	39.51	32	39.51
good	14	17.28	46	56.79
no opinion	3	3.70	49	60.49
very good	32	39.51	81	100.00

Q65	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Excellent	26	32.10	26	32.10
good	13	16.05	39	48.15
no opinion	6	7.41	45	55.56
no positive benefit	1	1.23	46	56.79
very good	35	43.21	81	100.00

Q66	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Excellent	31	38.27	31	38.27
good	15	18.52	46	56.79
no opinion	7	8.64	53	65.43
very good	27	33.33	80	98.77
very poor	1	1.23	81	100.00

Q67	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Excellent	27	33.33	27	33.33
good	12	14.81	39	48.15
no opinion	7	8.64	46	56.79
no positive benefit	1	1.23	47	58.02
poor	2	2.47	49	60.49
very good	32	39.51	81	100.00

- **SAS 9.1 analysis of: CMLES Social Negotiation: Questions (9-13)**

Q9	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	33	38.82	33	38.82
Almost Never	4	4.71	37	43.53
Don't Know	2	2.35	39	45.88
Often	24	28.24	63	74.12
Seldom	2	2.35	65	76.47
Sometimes	20	23.53	85	100.00

Q10	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	12	14.12	12	14.12
Almost Never	6	7.06	18	21.18
Don't Know	5	5.88	23	27.06
Often	27	31.76	50	58.82
Seldom	7	8.24	57	67.06
Sometimes	28	32.94	85	100.00

Q11	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	15	17.65	15	17.65
Almost Never	4	4.71	19	22.35
Don't Know	1	1.18	20	23.53
Often	24	28.24	44	51.76
Seldom	11	12.94	55	64.71
Sometimes	30	35.29	85	100.00

Q12	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	16	18.82	16	18.82
Almost Never	3	3.53	19	22.35
Don't Know	4	4.71	23	27.06
Often	18	21.18	41	48.24
Seldom	11	12.94	52	61.18
Sometimes	33	38.82	85	100.00

Q13	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	11	12.94	11	12.94
Almost Never	3	3.53	14	16.47
Don't Know	5	5.88	19	22.35
Often	24	28.24	43	50.59
Seldom	11	12.94	54	63.53
Sometimes	31	36.47	85	100.00

- **SAS 9.1 analysis of: CMLES Inquiry Learning Questions (14-18)**

Q14	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	22	25.88	22	25.88
Almost Never	2	2.35	24	28.24
Don't Know	1	1.18	25	29.41
Often	34	40.00	59	69.41
Seldom	3	3.53	62	72.94
Sometimes	23	27.06	85	100.00

Q15	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	20	23.53	20	23.53
Almost Never	4	4.71	24	28.24
Don't Know	2	2.35	26	30.59
Often	25	29.41	51	60.00
Seldom	7	8.24	58	68.24
Sometimes	27	31.76	85	100.00

Q16	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	12	14.12	12	14.12
Almost Never	4	4.71	16	18.82
Don't Know	2	2.35	18	21.18
Often	28	32.94	46	54.12
Seldom	10	11.76	56	65.88
Sometimes	29	34.12	85	100.00

Q17	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	15	17.65	15	17.65
Almost Never	5	5.88	20	23.53
Don't Know	3	3.53	23	27.06
Often	28	32.94	51	60.00
Seldom	8	9.41	59	69.41
Sometimes	26	30.59	85	100.00

Q18	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	27	31.76	27	31.76
Almost Never	5	5.88	32	37.65
Don't Know	1	1.18	33	38.82
Often	29	34.12	62	72.94
Seldom	4	4.71	66	77.65
Sometimes	19	22.35	85	100.00

- **SAS 9.1 analysis of: CMLES Reflective Thinking Questions (19-23)**

Q19	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	22	26.19	22	26.19
Almost Never	6	7.14	28	33.33
Don't Know	3	3.57	31	36.90
Often	26	30.95	57	67.86
Seldom	5	5.95	62	73.81
Sometimes	22	26.19	84	100.00

Q20	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	19	22.62	19	22.62
Almost Never	2	2.38	21	25.00
Don't Know	2	2.38	23	27.38
Often	38	45.24	61	72.62
Seldom	4	4.76	65	77.38
Sometimes	19	22.62	84	100.00

Q21	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	18	21.43	18	21.43
Almost Never	2	2.38	20	23.81
Don't Know	2	2.38	22	26.19
Often	31	36.90	53	63.10
Seldom	3	3.57	56	66.67
Sometimes	28	33.33	84	100.00

Q22	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	28	33.33	28	33.33
Almost Never	2	2.38	30	35.71
Don't Know	2	2.38	32	38.10
Often	31	36.90	63	75.00
Seldom	6	7.14	69	82.14
Sometimes	15	17.86	84	100.00

Q23	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	20	23.81	20	23.81
Almost Never	2	2.38	22	26.19
Don't Know	2	2.38	24	28.57
Often	36	42.86	60	71.43
Seldom	6	7.14	66	78.57
Sometimes	18	21.43	84	100.00

SAS 9.1 analysis of: CMLES Authenticity of Learning Questions (24A-27):

Q24	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	24	28.57	24	28.57
Almost Never	1	1.19	25	29.76
Don't Know	1	1.19	26	30.95
Often	33	39.29	59	70.24
Seldom	3	3.57	62	73.81
Sometimes	22	26.19	84	100.00

Q25	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	24	28.57	24	28.57
Almost Never	2	2.38	26	30.95
Don't Know	2	2.38	28	33.33
Often	35	41.67	63	75.00
Seldom	5	5.95	68	80.95
Sometimes	16	19.05	84	100.00

Q26	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	31	36.90	31	36.90
Almost Never	1	1.19	32	38.10
Don't Know	1	1.19	33	39.29
Often	29	34.52	62	73.81
Seldom	5	5.95	67	79.76
Sometimes	17	20.24	84	100.00

Q27	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	24	28.57	24	28.57
Almost Never	1	1.19	25	29.76
Don't Know	3	3.57	28	33.33
Often	31	36.90	59	70.24
Seldom	3	3.57	62	73.81
Sometimes	22	26.19	84	100.00

SAS 9.1 analysis: CMLES Complexity of the Learning Environment: Questions (28-32)

Q28	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	28	33.33	28	33.33
Almost Never	2	2.38	30	35.71
Don't Know	4	4.76	34	40.48
Often	36	42.86	70	83.33
Seldom	2	2.38	72	85.71
Sometimes	12	14.29	84	100.00

Q29	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	29	34.52	29	34.52
Almost Never	2	2.38	31	36.90
Don't Know	4	4.76	35	41.67
Often	33	39.29	68	80.95
Seldom	1	1.19	69	82.14
Sometimes	15	17.86	84	100.00

Q30	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	26	30.95	26	30.95
Almost Never	1	1.19	27	32.14
Don't Know	5	5.95	32	38.10
Often	31	36.90	63	75.00
Seldom	5	5.95	68	80.95
Sometimes	16	19.05	84	100.00

Q31	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	28	33.33	28	33.33
Almost Never	1	1.19	29	34.52
Don't Know	4	4.76	33	39.29
Often	31	36.90	64	76.19
Seldom	4	4.76	68	80.95
Sometimes	16	19.05	84	100.00

Q32	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	34	40.48	34	40.48
Almost Never	1	1.19	35	41.67
Don't Know	4	4.76	39	46.43
Often	26	30.95	65	77.38
Seldom	3	3.57	68	80.95
Sometimes	16	19.05	84	100.00

Ideal Learning Environment Questions:

SAS 9.1 analysis: CMLES Social Negotiation: Questions (33-37):

Q33	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	38	45.24	38	45.24
Almost Never	2	2.38	40	47.62
Don't Know	1	1.19	41	48.81
Often	28	33.33	69	82.14
Seldom	3	3.57	72	85.71
Sometimes	12	14.29	84	100.00

Q34	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	32	38.10	32	38.10
Almost Never	2	2.38	34	40.48
Don't Know	1	1.19	35	41.67
Often	29	34.52	64	76.19
Seldom	2	2.38	66	78.57
Sometimes	18	21.43	84	100.00

Q35	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	26	30.95	26	30.95
Almost Never	4	4.76	30	35.71
Don't Know	1	1.19	31	36.90
Often	33	39.29	64	76.19
Seldom	1	1.19	65	77.38
Sometimes	19	22.62	84	100.00

Q36	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	25	29.76	25	29.76
Almost Never	4	4.76	29	34.52
Don't Know	1	1.19	30	35.71
Often	32	38.10	62	73.81
Seldom	2	2.38	64	76.19
Sometimes	20	23.81	84	100.00

Q37	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	30	35.71	30	35.71
Almost Never	3	3.57	33	39.29
Don't Know	1	1.19	34	40.48
Often	28	33.33	62	73.81
Seldom	2	2.38	64	76.19
Sometimes	20	23.81	84	100.00

SAS 9.1 analysis: CMLES Inquiry Learning: Questions (38-42):

Q38	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	32	38.10	32	38.10
Almost Never	3	3.57	35	41.67
Often	27	32.14	62	73.81
Seldom	2	2.38	64	76.19
Sometimes	20	23.81	84	100.00

Q39	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	28	33.33	28	33.33
Almost Never	2	2.38	30	35.71
Often	38	45.24	68	80.95
Seldom	2	2.38	70	83.33
Sometimes	14	16.67	84	100.00

Q40	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	30	35.71	30	35.71
Almost Never	2	2.38	32	38.10
Often	26	30.95	58	69.05
Seldom	2	2.38	60	71.43
Sometimes	24	28.57	84	100.00

Q41	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	24	28.57	24	28.57
Almost Never	2	2.38	26	30.95
Often	38	45.24	64	76.19
Seldom	3	3.57	67	79.76
Sometimes	17	20.24	84	100.00

Q42	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	39	46.43	39	46.43
Almost Never	2	2.38	41	48.81
Don't Know	1	1.19	42	50.00
Often	29	34.52	71	84.52
Seldom	1	1.19	72	85.71
Sometimes	12	14.29	84	100.00

SAS 9.1 analysis: CMLES Reflective Thinking: Questions (43-47):

Q43	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	34	40.48	34	40.48
Almost Never	5	5.95	39	46.43
Often	34	40.48	73	86.90
Seldom	1	1.19	74	88.10
Sometimes	10	11.90	84	100.00

Q44	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	40	47.62	40	47.62
Almost Never	4	4.76	44	52.38
Often	29	34.52	73	86.90
Seldom	1	1.19	74	88.10
Sometimes	10	11.90	84	100.00

Q45	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	26	30.95	26	30.95
Almost Never	5	5.95	31	36.90
Don't Know	1	1.19	32	38.10
Often	29	34.52	61	72.62
Seldom	3	3.57	64	76.19
Sometimes	20	23.81	84	100.00

Q46	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	48	57.14	48	57.14
Almost Never	2	2.38	50	59.52
Often	21	25.00	71	84.52
Seldom	2	2.38	73	86.90
Sometimes	11	13.10	84	100.00

Q47	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	41	48.81	41	48.81
Almost Never	3	3.57	44	52.38
Don't Know	1	1.19	45	53.57
Often	28	33.33	73	86.90
Seldom	2	2.38	75	89.29
Sometimes	9	10.71	84	100.00

SAS 9.1 analysis: CMLES Authenticity of learning: Questions (48-52):

Q48	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	39	46.43	39	46.43
Almost Never	2	2.38	41	48.81
Don't Know	1	1.19	42	50.00
Often	27	32.14	69	82.14
Seldom	3	3.57	72	85.71
Sometimes	12	14.29	84	100.00

Q49	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	42	50.00	42	50.00
Almost Never	2	2.38	44	52.38
Don't Know	2	2.38	46	54.76
Often	28	33.33	74	88.10
Sometimes	10	11.90	84	100.00

Q50	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	43	51.19	43	51.19
Almost Never	2	2.38	45	53.57
Often	28	33.33	73	86.90
Seldom	2	2.38	75	89.29
Sometimes	9	10.71	84	100.00

Q51	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	42	50.00	42	50.00
Almost Never	2	2.38	44	52.38
Often	27	32.14	71	84.52
Sometimes	13	15.48	84	100.00

Q52	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	32	38.10	32	38.10
Almost Never	2	2.38	34	40.48
Often	35	41.67	69	82.14
Seldom	3	3.57	72	85.71
Sometimes	12	14.29	84	100.00

SAS 9.1 analysis: CMLES Complexity of the Learning Environment: Questions (53-57):

Q53	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	55	65.48	55	65.48
Almost Never	2	2.38	57	67.86
Don't Know	1	1.19	58	69.05
Often	21	25.00	79	94.05
Sometimes	5	5.95	84	100.00

Q54	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	54	64.29	54	64.29
Almost Never	2	2.38	56	66.67
Don't Know	1	1.19	57	67.86
Often	20	23.81	77	91.67
Seldom	2	2.38	79	94.05
Sometimes	5	5.95	84	100.00

Q55	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	42	50.00	42	50.00
Almost Never	3	3.57	45	53.57
Don't Know	1	1.19	46	54.76
Often	19	22.62	65	77.38
Seldom	4	4.76	69	82.14
Sometimes	15	17.86	84	100.00

Q56	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	54	64.29	54	64.29
Almost Never	2	2.38	56	66.67
Don't Know	1	1.19	57	67.86
Often	20	23.81	77	91.67
Seldom	1	1.19	78	92.86
Sometimes	6	7.14	84	100.00

Q57	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Almost Always	51	60.71	51	60.71
Almost Never	2	2.38	53	63.10
Don't Know	1	1.19	54	64.29
Often	22	26.19	76	90.48
Seldom	1	1.19	77	91.67
Sometimes	7	8.33	84	100.00

SAS Principal Component Factor Analysis with varimax rotation:

Eigenvalues of the Correlation Matrix: Total = 24 Average = 1				
	Eigenvalue	**Difference**	**Proportion**	**Cumulative**
1	10.2178007	7.1207869	0.4257	0.4257
2	3.0970138	1.4739909	0.1290	0.5548
3	1.6230230	0.0744693	0.0676	0.6224
4	1.5485537	0.4057710	0.0645	0.6869
5	1.1427827	0.3290841	0.0476	0.7345
6	0.8136985	0.1144313	0.0339	0.7685
7	0.6992672	0.0699802	0.0291	0.7976
8	0.6292870	0.0123330	0.0262	0.8238
9	0.6169540	0.0757812	0.0257	0.8495
10	0.5411727	0.0794129	0.0225	0.8721
11	0.4617598	0.0747147	0.0192	0.8913
12	0.3870451	0.0162638	0.0161	0.9074
13	0.3707813	0.0585933	0.0154	0.9229
14	0.3121880	0.0248938	0.0130	0.9359
15	0.2872942	0.0609277	0.0120	0.9479
16	0.2263666	0.0284847	0.0094	0.9573
17	0.1978819	0.0155780	0.0082	0.9655
18	0.1823039	0.0113806	0.0076	0.9731
19	0.1709233	0.0242744	0.0071	0.9803

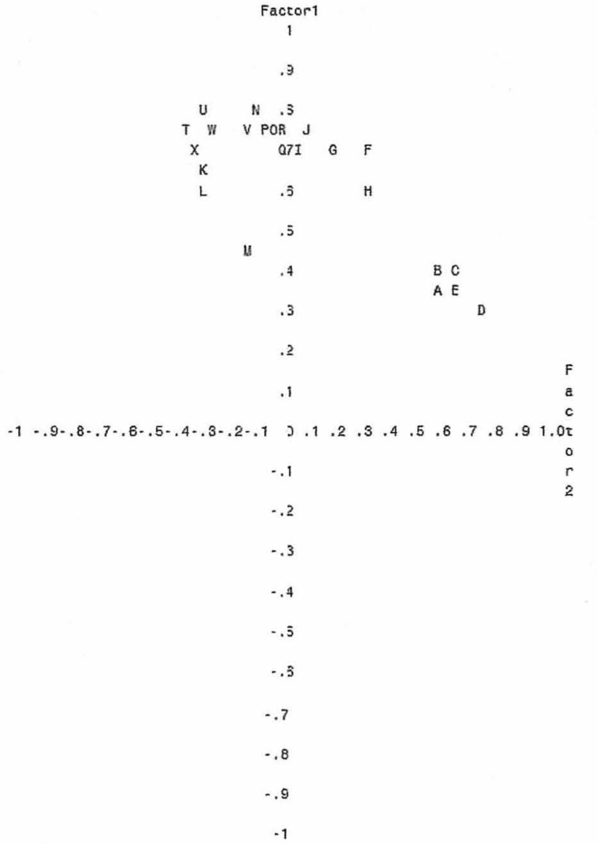
Eigenvalues of the Correlation Matrix: Total = 24 Average = 1				
	Eigenvalue	**Difference**	**Proportion**	**Cumulative**
20	0.1466489	0.0444939	0.0061	0.9864
21	0.1021550	0.0161361	0.0043	0.9906
22	0.0860189	0.0069303	0.0036	0.9942
23	0.0790886	0.0190974	0.0033	0.9975
24	0.0599912		0.0025	1.0000

Eigenvalues of the Correlation Matrix: Total = 24 Average = 1				
	Eigenvalue	Difference	Proportion	Cumulative
1	10.2178007	7.1207869	0.4257	0.4257
2	3.0970138	1.4739909	0.1290	0.5548
3	1.6230230	0.0744693	0.0676	0.6224
4	1.5485537	0.4057710	0.0645	0.6869
5	1.1427827	0.3290841	0.0476	0.7345
6	0.8136985	0.1144313	0.0339	0.7685
7	0.6992672	0.0699802	0.0291	0.7976
8	0.6292870	0.0123330	0.0262	0.8238
9	0.6169540	0.0757812	0.0257	0.8495
10	0.5411727	0.0794129	0.0225	0.8721
11	0.4617598	0.0747147	0.0192	0.8913
12	0.3870451	0.0162638	0.0161	0.9074
13	0.3707813	0.0585933	0.0154	0.9229
14	0.3121880	0.0248938	0.0130	0.9359
15	0.2872942	0.0609277	0.0120	0.9479
16	0.2263666	0.0284847	0.0094	0.9573
17	0.1978819	0.0155780	0.0082	0.9655
18	0.1823039	0.0113806	0.0076	0.9731
19	0.1709233	0.0242744	0.0071	0.9803
20	0.1466489	0.0444939	0.0061	0.9864
21	0.1021550	0.0161361	0.0043	0.9906
22	0.0860189	0.0069303	0.0036	0.9942
23	0.0790886	0.0190974	0.0033	0.9975
24	0.0599912		0.0025	1.0000

Factor Pattern						
		Factor1	Factor2	Factor3	Factor4	Factor5
Q9	Communiate with eachother	0.33220	0.59332	0.28350	0.09591	0.04056
Q10	Communiate with eachother about conduting investigations	0.41062	0.58654	0.25168	-0.10513	0.05979
Q11	Ask other students to explain their ideas	0.38728	0.65159	0.27239	0.00974	0.09094
Q12	Ask me to explain ideas	0.28954	0.76533	0.25673	0.07547	0.00775
Q13	Other students respond carefully to my ideas	0.35205	0.65409	0.17809	0.16732	-0.08460
Q14	Q14	0.67924	0.31357	-0.12843	-0.15942	0.15132
Q15	Q15	0.69943	0.19330	-0.43368	-0.24410	0.01782
Q16	Q16	0.62330	0.31973	-0.43997	-0.38107	0.05642
Q17	Q17	0.69473	0.04658	-0.31267	-0.46246	-0.04111
Q18	Q18	0.73754	0.07423	-0.19233	-0.16644	0.19612
Q19	Q19	0.62659	-0.30699	0.08240	-0.19180	0.23591
Q20	Q20	0.59371	-0.31008	-0.02286	0.14968	0.52654
Q21	Q21	0.44650	-0.14438	0.02034	0.52836	0.44086
Q22	Q22	0.79058	-0.12776	-0.05886	0.11362	0.16764
Q23	Q23	0.75847	-0.05125	-0.06883	0.22799	0.26189
Q24	Q24	0.75148	-0.07107	-0.16969	0.39900	-0.26501
Q25	Q25	0.67816	-0.01985	-0.30110	0.43243	-0.29824
Q26	Q26	0.73198	-0.00309	-0.04073	0.32870	-0.26626
Q27	Q27	0.78965	0.00926	-0.27372	0.20271	-0.28809
Q28	Q28	0.76867	-0.36979	0.37051	-0.09537	-0.04338
Q29	Q29	0.79681	-0.33178	0.34119	-0.12313	-0.02036
Q30	Q30	0.76169	-0.14323	0.12456	-0.22427	-0.25964
Q31	Q31	0.77467	-0.29877	0.37567	-0.16696	-0.16949
Q32	Q32	0.69325	-0.35339	0.39024	-0.14741	-0.14170

The FACTOR Procedure
Initial Factor Method: Principal Components

Plot of Factor Pattern for Factor1 and Factor2



Q9=A	Q10=B	Q11=C	Q12=D	Q13=E	Q14=F	Q15=G	Q16=H	Q17=I
Q18=J	Q19=K	Q20=L	Q21=M	Q22=N	Q23=O	Q24=P	Q25=Q	Q26=R
Q27=S	Q28=T	Q29=U	Q30=V	Q31=W	Q32=X			

Factor Analysis

The FACTOR Procedure
Rotation Method: Varimax

Orthogonal Transformation Matrix					
	1	2	3	4	5
1	0.58699	0.48682	0.28734	0.46292	0.34871
2	-0.43995	0.19222	0.85418	-0.02525	-0.19809
3	0.57968	-0.61115	0.42077	-0.33598	-0.02327
4	-0.30675	-0.57800	0.09232	0.60720	0.44113
5	-0.17823	0.13591	0.04744	-0.55090	0.80251

Rotated Factor Pattern						
		Factor1	Factor2	Factor3	Factor4	Factor5
Q9	Communiate with eachother	0.06165	0.05258	0.73232	0.07944	0.06658
Q10	Communiate with eachother about conduting investigations	0.15046	0.22772	0.71803	-0.00606	0.02275
Q11	Ask other students to explain their ideas	0.07936	0.15404	0.78768	0.02712	0.07692
Q12	Ask me to explain ideas	-0.04246	0.08860	0.85228	0.07001	-0.01710
Q13	Other students respond carefully to my ideas	-0.01413	0.08006	0.74624	0.23482	-0.00503
Q14	Q14	0.20823	0.58214	0.40144	0.16950	0.22885
Q15	Q15	0.14582	0.78621	0.16191	0.30657	0.12232
Q16	Q16	0.07700	0.86171	0.23457	0.16582	0.04143
Q17	Q17	0.35524	0.79996	0.06320	0.16732	0.00332
Q18	Q18	0.30488	0.61372	0.18833	0.19506	0.33093
Q19	Q19	0.56742	0.33859	-0.05402	0.02370	0.38210
Q20	Q20	0.33191	0.22844	-0.06509	0.09116	0.75757
Q21	Q21	0.09675	-0.06829	0.08323	0.28145	0.77070
Q22	Q22	0.42142	0.35340	0.11171	0.36561	0.48702
Q23	Q23	0.31124	0.30527	0.17867	0.36969	0.58699
Q24	Q24	0.29885	0.18924	0.10809	0.79495	0.24342
Q25	Q25	0.15277	0.21986	0.07699	0.84247	0.19884
Q26	Q26	0.35404	0.15446	0.20826	0.69887	0.18814
Q27	Q27	0.28994	0.39716	0.12468	0.73906	0.13813
Q28	Q28	0.86565	0.12592	0.05003	0.20668	0.25579
Q29	Q29	0.85287	0.18401	0.07678	0.19905	0.26498
Q30	Q30	0.69739	0.36149	0.11590	0.32122	-0.01621
Q31	Q31	0.88535	0.16357	0.10200	0.23193	0.11091
Q32	Q32	0.85909	0.09701	0.04121	0.18728	0.12392

Variance Explained by Each Factor				
Factor1	Factor2	Factor3	Factor4	Factor5
4.8474271	3.6806252	3.4063558	3.2925432	2.4022226

Factor Loading (Questions 1 – 24 [Survey Monkey Q9 – Q32])

Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22
0.55360266	0.59061107	0.65712300	0.74123115	0.61865010	0.62449884	0.77454695	0.83271045	0.79813498	0.65263660	0.58608591	0.74880968	0.69413794	0.68582184

Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32
0.70320661	0.82800572	0.82690441	0.71639594	0.82264212	0.87585924	0.87697478	0.73390771	0.88709923	0.79957698

Factor Analysis

The FACTOR Procedure
Rotation Method: Varimax

```
Plot of Factor Pattern for Factor1 and Factor2

                            Factor1
                                1

                               .9   W
                                  XT U
                               .8

                               .7        V

                               .6
                                         K
                               .5

                               .4        N
                                    R L                I
                               .3    P  O S      J

                               .2               F
                                      B                G        F
                             M .1   C                    H      a
                                 A                              c
-1 -.9-.8-.7-.6-.5-.4-.3-.2-.1  0 E1 .2 .3 .4 .5 .6 .7 .8 .9 1.0t
                                  D                             o
                              -.1                               r
                                                                2
                              -.2

                              -.3

                              -.4

                              -.5

                              -.6

                              -.7

                              -.8

                              -.9

                               -1

Q9=A      Q10=B     Q11=C     Q12=D     Q13=E     Q14=F     Q15=G     Q16=H     Q17=I
Q18=J     Q19=K     Q20=L     Q21=M     Q22=N     Q23=O     Q24=P     Q25=B     Q26=R
Q27=S     Q28=T     Q29=U     Q30=V     Q31=W     Q32=X
```

Current Class

Factor Analysis

The CORR Procedure

Simple Statistics							
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum	Label
Q9	85	3.91765	1.19734	333.00000	0	5.00000	Communiate with eachother
Q10	85	3.20000	1.32557	272.00000	0	5.00000	Communiate with eachother about conduting investigations
Q11	85	3.37647	1.13365	287.00000	0	5.00000	Ask other students to explain their ideas
Q12	85	3.24706	1.27154	276.00000	0	5.00000	Ask me to explain ideas
Q13	85	3.16471	1.26158	269.00000	0	5.00000	Other students respond carefully to my ideas
Q14	85	3.80000	1.02120	323.00000	0	5.00000	Q14
Q15	85	3.51765	1.21118	299.00000	0	5.00000	Q15
Q16	85	3.32941	1.14838	283.00000	0	5.00000	Q16
Q17	85	3.35294	1.25077	285.00000	0	5.00000	Q17
Q18	85	3.77647	1.18900	321.00000	0	5.00000	Q18
Q19	85	3.48235	1.37678	296.00000	0	5.00000	Q19
Q20	85	3.69412	1.15494	314.00000	0	5.00000	Q20
Q21	85	3.60000	1.14642	306.00000	0	5.00000	Q21
Q22	85	3.80000	1.24212	323.00000	0	5.00000	Q22
Q23	85	3.67059	1.18912	312.00000	0	5.00000	Q23
Q24	85	3.82353	1.07101	325.00000	0	5.00000	Q24
Q25	85	3.76471	1.20166	320.00000	0	5.00000	Q25
Q26	85	3.91765	1.13611	333.00000	0	5.00000	Q26
Q27	85	3.72941	1.21878	317.00000	0	5.00000	Q27
Q28	85	3.88235	1.27626	330.00000	0	5.00000	Q28
Q29	85	3.88235	1.27626	330.00000	0	5.00000	Q29
Q30	85	3.68235	1.37332	313.00000	0	5.00000	Q30
Q31	85	3.77647	1.31273	321.00000	0	5.00000	Q31
Q32	85	3.87059	1.33442	329.00000	0	5.00000	Q32

Cronbach Coefficient Alpha with Deleted Variable					
	Raw Variables		Standardized Variables		
Deleted Variable	Correlation with Total	Alpha	Correlation with Total	Alpha	Label
Q9	0.600578	0.826393	0.601346	0.828181	Communiate with eachother
Q10	0.618272	0.823331	0.617743	0.823862	Communiate with eachother about conduting investigations
Q11	0.674818	0.808342	0.675460	0.808388	Ask other students to explain their ideas
Q12	0.733041	0.790165	0.732475	0.792682	Ask me to explain ideas
Q13	0.639368	0.816495	0.640290	0.817867	Other students respond carefully to my ideas

Cronbach Coefficient Alpha with Deleted Variable					
	Raw Variables		Standardized Variables		
Deleted Variable	Correlation with Total	Alpha	Correlation with Total	Alpha	Label
Q9	0.600578	0.826393	0.601346	0.828181	Communiate with eachother
Q14	0.688899	0.852099	0.692033	0.853063	Q14
Q24	0.689637	0.917662	0.692391	0.918743	Q24
Q19	0.314926	0.870643	0.317987	0.873075	Q19
Q28	0.704790	0.931315	0.697123	0.932104	Q28

Pearson's Correlation Coefficients

Pearson Correlation Coefficients, N = 85
Prob > |r| under H0: Rho=0

	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32
Q9 Communiate with eachother	1.00000	0.48304 <.0001	0.51426 <.0001	0.49833 <.0001	0.45831 <.0001	0.35635 0.0008	0.20214 0.0636	0.21910 0.0439	0.11503 0.2945	0.30468 0.0046	0.06049 0.5823	0.05905 0.5914	0.09714 0.3765	0.17290 0.1136	0.17303 0.1133	0.16492 0.1315	0.25115 0.0204	0.16999 0.1199	0.23744 0.0287	0.14939 0.1724	0.15718 0.1508	0.15766 0.1496	0.16993 0.1200	0.07521 0.4939
Q10 Communiate with eachother about conduting investigations	0.48304 <.0001	1.00000	0.48800 <.0001	0.57775 <.0001	0.44990 <.0001	0.39047 0.0002	0.32033 0.0028	0.39415 0.0002	0.27285 0.0115	0.27041 0.0123	0.11611 0.2900	0.12597 0.2506	0.10811 0.3247	0.16919 0.1216	0.26887 0.0128	0.18448 0.0910	0.15695 0.1514	0.24031 0.0267	0.26233 0.0153	0.15481 0.1572	0.18296 0.0937	0.27074 0.0122	0.23808 0.0282	0.24363 0.0246
Q11 Ask other students to explain their ideas	0.51426 <.0001	0.48800 <.0001	1.00000	0.61192 <.0001	0.53880 <.0001	0.41544 <.0001	0.32458 0.0024	0.30596 0.0044	0.25780 0.0172	0.27514 0.0108	0.05770 0.5999	0.07991 0.4572	0.14473 0.1863	0.16401 0.1336	0.25205 0.0200	0.23186 0.0327	0.13571 0.2156	0.29241 0.0066	0.16077 0.1416	0.18731 0.0861	0.20377 0.0614	0.22301 0.0402	0.16922 0.1216	0.09555 0.3844
Q12 Ask me to explain ideas	0.49833 <.0001	0.57775 <.0001	0.61192 <.0001	1.00000	0.51256 <.0001	0.38689 0.0003	0.14014 0.2008	0.33494 0.0017	0.11668 0.2876	0.17870 0.1018	-0.02128 0.8457	-0.04521 0.6812	0.05227 0.6347	0.22763 0.0362	0.17257 0.1143	0.13730 0.2102	0.10862 0.3224	0.23675 0.0291	0.19729 0.0703	0.00345 0.9750	0.05480 0.6184	0.16137 0.1401	0.06914 0.5295	0.01205 0.9128
Q13 Other students respond carefully to my ideas	0.45831 <.0001	0.44990 <.0001	0.53880 <.0001	0.61256 <.0001	1.00000	0.31233 0.0036	0.31751 0.0031	0.24970 0.0212	0.14379 0.1892	0.20737 0.0569	0.11821 0.2813	-0.03037 0.7826	0.05433 0.6214	0.20360 0.0616	0.33021 0.0020	0.25085 0.0206	0.22219 0.0410	0.30028 0.0052	0.28483 0.0082	0.05654 0.6073	0.12308 0.2618	0.14050 0.1997	0.14470 0.1864	0.06231 0.5710
Q14 Q14	0.35635 0.0008	0.39047 0.0002	0.41544 <.0001	0.38689 0.0003	0.31233 0.0036	1.00000	0.53708 <.0001	0.63548 <.0001	0.55922 <.0001	0.62945 <.0001	0.28111 0.0092	0.34116 0.0014	0.27659 0.0104	0.48428 <.0001	0.40587 0.0001	0.43539 <.0001	0.38865 0.0005	0.47816 <.0001	0.44381 <.0001	0.41104 <.0001	0.41104 <.0001	0.42953 <.0001	0.40140 0.0001	0.32149 0.0027
Q15 Q15	0.20214 0.0636	0.32033 0.0028	0.32458 0.0024	0.14014 0.2008	0.31751 0.0031	0.53708 <.0001	1.00000	0.73186 <.0001	0.69524 <.0001	0.65171 <.0001	0.34822 0.0011	0.29326 0.0065	0.19377 0.0756	0.44156 <.0001	0.59096 <.0001	0.46589 <.0001	0.50184 <.0001	0.35145 0.0010	0.62022 <.0001	0.33252 0.0019	0.41724 <.0001	0.45789 <.0001	0.40309 0.0001	0.32184 0.0027
Q16 Q16	0.21910 0.0439	0.39415 0.0002	0.30596 0.0044	0.33494 0.0017	0.24970 0.0212	0.63548 <.0001	0.73186 <.0001	1.00000	0.68889 <.0001	0.54282 <.0001	0.37267 0.0004	0.27434 0.0111	0.07415 0.5000	0.45569 <.0001	0.38554 0.0003	0.37692 0.0004	0.36741 0.0005	0.33128 0.0020	0.51525 <.0001	0.22982 0.0344	0.27044 0.0123	0.48231 <.0001	0.24685 0.0228	0.24567 0.0234
Q17 Q17	0.11503 0.2945	0.27285 0.0115	0.25780 0.0172	0.11668 0.2876	0.14379 0.1892	0.55922 <.0001	0.69524 <.0001	0.68889 <.0001	1.00000	0.62203 <.0001	0.45993 <.0001	0.30637 0.0043	0.09963 0.3643	0.52106 <.0001	0.38326 0.0003	0.38475 0.0003	0.35690 0.0008	0.45633 <.0001	0.53196 <.0001	0.45887 <.0001	0.48124 <.0001	0.57891 <.0001	0.47640 <.0001	0.38432 0.0003
Q18 Q18	0.30468 0.0046	0.27041 0.0123	0.27514 0.0108	0.17870 0.1018	0.20737 0.0569	0.62945 <.0001	0.65171 <.0001	0.54282 <.0001	0.62203 <.0001	1.00000	0.37936 0.0003	0.44376 <.0001	0.31790 0.0030	0.55780 <.0001	0.53670 <.0001	0.45478 <.0001	0.46268 <.0001	0.44448 <.0001	0.49174 <.0001	0.50024 <.0001	0.51593 <.0001	0.46635 <.0001	0.52439 <.0001	0.40923 0.0001
Q19 Q19	0.06049 0.5823	0.11611 0.2900	0.05770 0.5999	-0.02128 0.8467	0.11821 0.2813	0.28111 0.0092	0.34822 0.0011	0.37267 0.0004	0.45993 <.0001	0.37936 0.0003	1.00000	0.59551 <.0001	0.19158 0.0790	0.54438 <.0001	0.51269 <.0001	0.34099 0.0014	0.29249 0.0066	0.35297 0.0009	0.42635 <.0001	0.56114 <.0001	0.62211 <.0001	0.45348 <.0001	0.55439 <.0001	0.53981 <.0001
Q20 Q20	0.05905 0.5914	0.12597 0.2506	0.07991 0.4672	-0.04521 0.6812	-0.03037 0.7826	0.34116 0.0014	0.29326 0.0065	0.27434 0.0111	0.30637 0.0043	0.44376 <.0001	0.59551 <.0001	1.00000	0.47293 <.0001	0.55434 <.0001	0.55855 <.0001	0.47555 <.0001	0.35068 0.0010	0.38885 0.0002	0.32954 0.0021	0.49219 <.0001	0.53257 <.0001	0.36584 0.0006	0.41764 <.0001	0.36796 0.0005
Q21 Q21	0.09714 0.3765	0.10811 0.3247	0.14473 0.1863	0.05227 0.6347	0.05433 0.6214	0.27659 0.0104	0.19377 0.0756	0.07415 0.5000	0.09963 0.3843	0.31790 0.0030	0.19158 0.0790	0.47293 <.0001	1.00000	0.45312 <.0001	0.49729 <.0001	0.40722 0.0001	0.36295 0.0006	0.35829 0.0008	0.32206 0.0026	0.35800 0.0008	0.31732 0.0031	0.19811 0.0691	0.23257 0.0322	0.31594 0.0032
Q22 Q22	0.17290 0.1136	0.16919 0.1216	0.16401 0.1336	0.22763 0.0362	0.20360 0.0616	0.48428 <.0001	0.44156 <.0001	0.45569 <.0001	0.52106 <.0001	0.55780 <.0001	0.54438 <.0001	0.55434 <.0001	0.45312 <.0001	1.00000	0.70444 <.0001	0.58167 <.0001	0.45462 <.0001	0.58714 <.0001	0.65584 <.0001	0.59326 <.0001	0.60077 <.0001	0.59042 <.0001	0.57094 <.0001	0.48696 <.0001
Q23 Q23	0.17303 0.1133	0.26887 0.0128	0.25205 0.0200	0.17257 0.1143	0.33021 0.0020	0.40587 0.0001	0.59096 <.0001	0.38554 0.0003	0.38326 0.0003	0.53670 <.0001	0.51269 <.0001	0.55855 <.0001	0.48729 <.0001	0.70444 <.0001	1.00000	0.52402 <.0001	0.56163 <.0001	0.48196 <.0001	0.62776 <.0001	0.53895 <.0001	0.58602 <.0001	0.43088 <.0001	0.50900 <.0001	0.45297 <.0001
Q24 Q24	0.16492 0.1315	0.18448 0.0910	0.23186 0.0327	0.13730 0.2102	0.25085 0.0206	0.43539 <.0001	0.46589 <.0001	0.37692 0.0004	0.38475 0.0003	0.45478 <.0001	0.34099 0.0014	0.47555 <.0001	0.40722 0.0001	0.58167 <.0001	0.52402 <.0001	1.00000	0.79986 <.0001	0.73148 <.0001	0.71995 <.0001	0.48977 <.0001	0.52461 <.0001	0.56038 <.0001	0.52199 <.0001	0.45030 <.0001
																				0.38538 0.0003	0.41643 <.0001	0.42307 <.0001	0.41907 <.0001	0.35199 0.0010
Q25 Q25	0.25115 0.0204	0.15695 0.1514	0.13571 0.2156	0.10862 0.3224	0.22219 0.0410	0.38865 0.0005	0.50184 <.0001	0.36741 0.0005	0.35690 0.0008	0.46268 <.0001	0.29249 0.0066	0.35068 0.0010	0.36295 0.0006	0.45462 <.0001	0.56163 <.0001	0.79986 <.0001	1.00000	0.64836 <.0001	0.74448 <.0001	0.55154 <.0001	0.49407 <.0001	0.48662 <.0001	0.50636 <.0001	0.47189 <.0001
Q26 Q26	0.16999 0.1199	0.24031 0.0267	0.29241 0.0066	0.23675 0.0291	0.30028 0.0052	0.47816 <.0001	0.35145 0.0010	0.33128 0.0020	0.45633 <.0001	0.44448 <.0001	0.35297 0.0009	0.38865 0.0002	0.35829 0.0008	0.58714 <.0001	0.48196 <.0001	0.73148 <.0001	0.64836 <.0001	1.00000	0.68871 <.0001	0.49207 <.0001	0.51503 <.0001	0.60950 <.0001	0.49748 <.0001	0.42472 <.0001
Q27 Q27	0.23744 0.0287	0.26233 0.0153	0.16077 0.1416	0.19729 0.0703	0.28483 0.0082	0.44381 <.0001	0.62022 <.0001	0.51525 <.0001	0.53196 <.0001	0.49174 <.0001	0.42635 <.0001	0.32954 0.0021	0.32206 0.0026	0.65584 <.0001	0.62776 <.0001	0.71995 <.0001	0.74448 <.0001	0.68871 <.0001	1.00000	1.00000	0.89768 <.0001	0.69160 <.0001	0.85101 <.0001	0.76686 <.0001
Q28 Q28	0.14939 0.1724	0.15481 0.1572	0.18731 0.0861	0.00345 0.9750	0.05654 0.6073	0.41104 <.0001	0.33252 0.0019	0.22982 0.0344	0.45887 <.0001	0.50024 <.0001	0.56114 <.0001	0.49219 <.0001	0.35800 0.0008	0.59326 <.0001	0.53895 <.0001	0.48977 <.0001	0.38538 0.0003	0.55154 <.0001	0.49207 <.0001	0.89768 <.0001	1.00000	0.69840 <.0001	0.85101 <.0001	0.76686 <.0001
Q29 Q29	0.15718 0.1508	0.18296 0.0937	0.20377 0.0614	0.05480 0.6184	0.12308 0.2618	0.41104 <.0001	0.41724 <.0001	0.27044 0.0123	0.48124 <.0001	0.51593 <.0001	0.62211 <.0001	0.53257 <.0001	0.31732 0.0031	0.60077 <.0001	0.58602 <.0001	0.52461 <.0001	0.41643 <.0001	0.49407 <.0001	0.51503 <.0001	0.89768 <.0001	1.00000	0.69840 <.0001	0.85101 <.0001	0.76686 <.0001
Q30 Q30	0.15766 0.1496	0.27074 0.0122	0.22301 0.0402	0.16137 0.1401	0.14050 0.1997	0.42953 <.0001	0.45789 <.0001	0.48231 <.0001	0.57891 <.0001	0.46635 <.0001	0.45348 <.0001	0.36584 0.0006	0.19811 0.0691	0.59042 <.0001	0.43088 <.0001	0.56038 <.0001	0.42307 <.0001	0.48662 <.0001	0.60950 <.0001	0.69160 <.0001	0.69840 <.0001	1.00000	0.69974 <.0001	0.65940 <.0001
Q31 Q31	0.16993 0.1200	0.23808 0.0282	0.16922 0.1216	0.06914 0.5295	0.14470 0.1864	0.40140 0.0001	0.40309 0.0001	0.24685 0.0228	0.47640 <.0001	0.52439 <.0001	0.55439 <.0001	0.41764 <.0001	0.23257 0.0322	0.57094 <.0001	0.50900 <.0001	0.52199 <.0001	0.41907 <.0001	0.50636 <.0001	0.49748 <.0001	0.85101 <.0001	0.85101 <.0001	0.69974 <.0001	1.00000	0.83959 <.0001
Q32 Q32	0.07521 0.4939	0.24363 0.0246	0.09555 0.3844	0.01205 0.9128	0.06231 0.5710	0.32149 0.0027	0.32184 0.0027	0.24567 0.0234	0.38432 0.0003	0.40923 0.0001	0.53981 <.0001	0.36796 0.0005	0.31594 0.0032	0.48696 <.0001	0.45297 <.0001	0.45030 <.0001	0.35199 0.0010	0.47189 <.0001	0.42472 <.0001	0.76686 <.0001	0.76686 <.0001	0.65940 <.0001	0.83959 <.0001	1.00000

Ideal Class

Variance Explained by Each Factor				
Factor1	Factor2	Factor3	Factor4	Factor5
4.8043819	4.2477777	4.1641438	3.7135347	3.3019461

Final Communality Estimates: Total = 20.231784

Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45	Q46	Q47
0.85754153	0.87786925	0.83176740	0.82671528	0.78900201	0.80641776	0.86184794	0.83841927	0.84392474	0.64794439	0.81801613	0.82171537	0.73795842	0.79381035	0.81819542

Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56	Q57
0.80863768	0.74199018	0.76705351	0.72844342	0.80617153	0.93295253	0.91694810	0.59481743	0.93677947	0.82684503

Factor Analysis

The FACTOR Procedure
Initial Factor Method: Principal Components

Prior Communality Estimates: ONE

Eigenvalues of the Correlation Matrix: Total = 25 Average = 1				
	Eigenvalue	Difference	Proportion	Cumulative
1	14.9709264	12.9844490	0.5988	0.5988
2	1.9864774	0.5435588	0.0795	0.6783
3	1.4429186	0.4588879	0.0577	0.7360
4	0.9840307	0.1365998	0.0394	0.7754
5	0.8474309	0.1347022	0.0339	0.8093
6	0.7127288	0.1818661	0.0285	0.8378
7	0.5308627	0.0843840	0.0212	0.8590
8	0.4464787	0.0740076	0.0179	0.8769
9	0.3724710	0.0357203	0.0149	0.8918
10	0.3367508	0.0192633	0.0135	0.9052
11	0.3174875	0.0512729	0.0127	0.9179
12	0.2662146	0.0230132	0.0106	0.9286
13	0.2432014	0.0165985	0.0097	0.9383
14	0.2266028	0.0249614	0.0091	0.9474
15	0.2016415	0.0020837	0.0081	0.9554

16	0.1995578	0.0304851	0.0080	0.9634
17	0.1690727	0.0064096	0.0068	0.9702
18	0.1626631	0.0272468	0.0065	0.9767
19	0.1354163	0.0144400	0.0054	0.9821
20	0.1209763	0.0392317	0.0048	0.9870
21	0.0817445	0.0043851	0.0033	0.9902
22	0.0773595	0.0045560	0.0031	0.9933
23	0.0728034	0.0215112	0.0029	0.9962
24	0.0512922	0.0084019	0.0021	0.9983
25	0.0428903		0.0017	1.0000

Simple Statistics							
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum	Label
Q33	85	4.07059	1.15252	346.00000	0	5.00000	'
Q34	85	3.95294	1.13290	336.00000	0	5.00000	'
Q35	85	3.82353	1.16677	325.00000	0	5.00000	'
Q36	85	3.77647	1.17895	321.00000	0	5.00000	'
Q37	85	3.87059	1.17299	329.00000	0	5.00000	'
Q38	85	3.94118	1.10575	335.00000	0	5.00000	'
Q39	85	4.00000	1.00000	340.00000	0	5.00000	'
Q40	85	3.90588	1.06484	332.00000	0	5.00000	'
Q41	85	3.89412	1.01211	331.00000	0	5.00000	'
Q42	85	4.12941	1.11043	351.00000	0	5.00000	'
Q43	85	4.03529	1.13858	343.00000	0	5.00000	'
Q44	85	4.14118	1.11433	352.00000	0	5.00000	'
Q45	85	3.72941	1.23817	317.00000	0	5.00000	'
Q46	85	4.27059	1.06221	363.00000	0	5.00000	'
Q47	85	4.12941	1.17299	351.00000	0	5.00000	'
Q48	85	4.08235	1.15688	347.00000	0	5.00000	'
Q49	85	4.16471	1.17359	354.00000	0	5.00000	'
Q50	85	4.23529	1.03103	360.00000	0	5.00000	'
Q51	85	4.27059	0.94350	363.00000	0	5.00000	'
Q52	85	4.04706	1.03402	344.00000	0	5.00000	'
Q53	85	4.42353	1.06208	376.00000	0	5.00000	'
Q54	85	4.36471	1.12172	371.00000	0	5.00000	'
Q55	85	4.07059	1.21291	346.00000	0	5.00000	'
Q56	85	4.40000	1.07127	374.00000	0	5.00000	'
Q57	85	4.32941	1.10613	368.00000	0	5.00000	' Format Q33-Q57 LIKERT

Cronbach Coefficient Alpha with Deleted Variable					
	Raw Variables		Standardized Variables		
Deleted Variable	Correlation with Total	Alpha	Correlation with Total	Alpha	Label
Q33	0.869817	0.928462	0.870613	0.928678	'
Q34	0.859144	0.883694	0.858008	0.882719	'
Q39	0.849311	0.869901	0.852392	0.872579	'
Q44	0.832704	0.850978	0.830889	0.855546	'
Q53	0.910556	0.886928	0.915511	0.891807	'

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